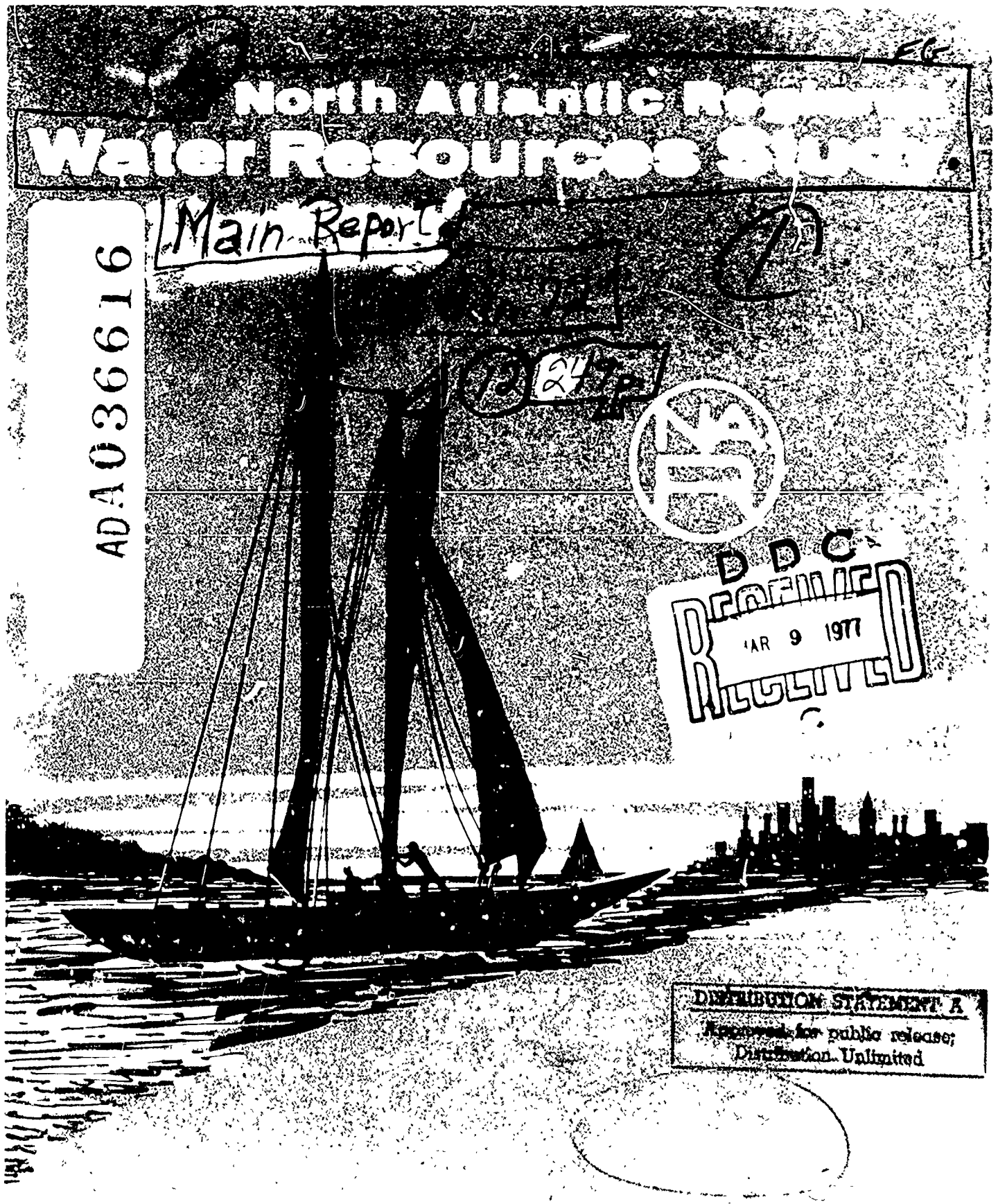
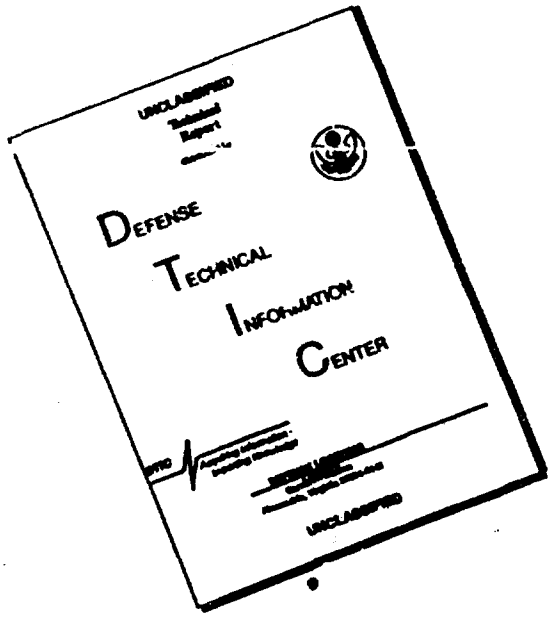


406959

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY COORDINATING COMMITTEE

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

Errata of Report and Annex 1
North Atlantic Regional Water Resources Study
September 31, 1972

REPORT

Page	
186	The Industrial Self-Supplied Water need is for fresh water only and does not include brackish and saline water. The costs and devices for this need are for all types of water.
192	The cost for "Flood Damage Reduction - mainstreams" should be 790 in 1980 rather than 700.
195	The need for "landscape maintenance-diversity" should be 10.3 in 2020 rather than 10.2

ANNEX I

Page	
19	The Industrial Self-Supplied Water need is for fresh water only and does not include brackish and saline water. The costs and devices for this need are for all types of water.
88,89	The needs for "mainstream Flood Damage Reduction" and "tidal and hurricane Flood Damage Reduction" should be 0.04, 0.04, 0.09, 0.18 and 0.01, 0.02, 0.04, 0.07 respectively for the present and three target years for both the mixed objective and the National Income objective. The present figures are 0.036, 0.043, 0.090, 0.130, and 0.014, 0.017, 0.036, and 0.070.
126	The device "mainstream storage reservoirs" should be 53 in 2000 rather than 54 for the mixed objective.
140	The cost for "Flood Damage Reduction - mainstream" should be 90 in 1980 rather than 0 for the mixed objective. The summation of costs in 1980 should be 2200 rather than 2100.
250,251	The device "ocean-local Flood Protection" should be 0 in 1980 for the mixed objective and all single objectives rather than 1.
300,301	The device "ocean-Local Flood Protection" should be 2 in 1980 for the mixed objective and all single objectives rather than 1.

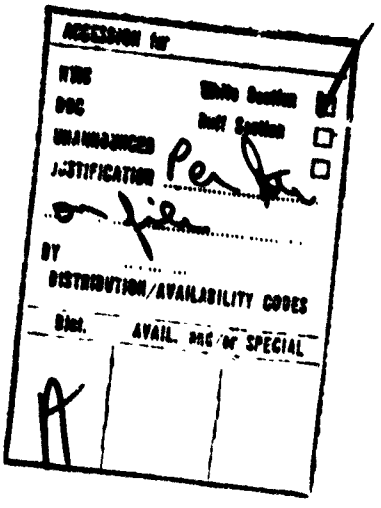
The North Atlantic Regional Water Resources (NAR) Study examined a wide variety of water and related land resources, needs and devices in formulating a broad, coordinated program to guide future resource development and management in the North Atlantic Region. The Study was authorized by the 1965 Water Resources Planning Act (PL 89-80) and the 1965 Flood Control Act (PL 89-298), and carried out under guidelines set by the Water Resources Council.

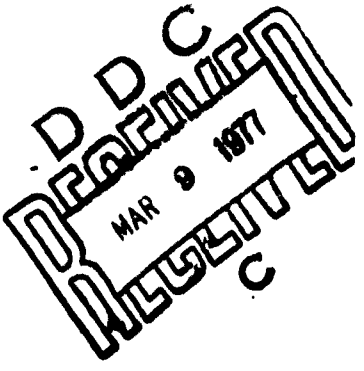
The recommended program and alternatives developed for the North Atlantic Region were prepared under the direction of the NAR Study Coordinating Committee, a partnership of resource planners representing some 25 Federal, regional and State agencies. The NAR Study Report presents this program and the alternatives as a framework for future action based on a planning period running through 2020, with bench mark planning years of 1980 and 2000.

The planning partners focused on three major objectives -- National Income, Regional Development and Environmental Quality -- in developing and documenting the information which decision-makers will need for managing water and related land resources in the interest of the people of the North Atlantic Region.

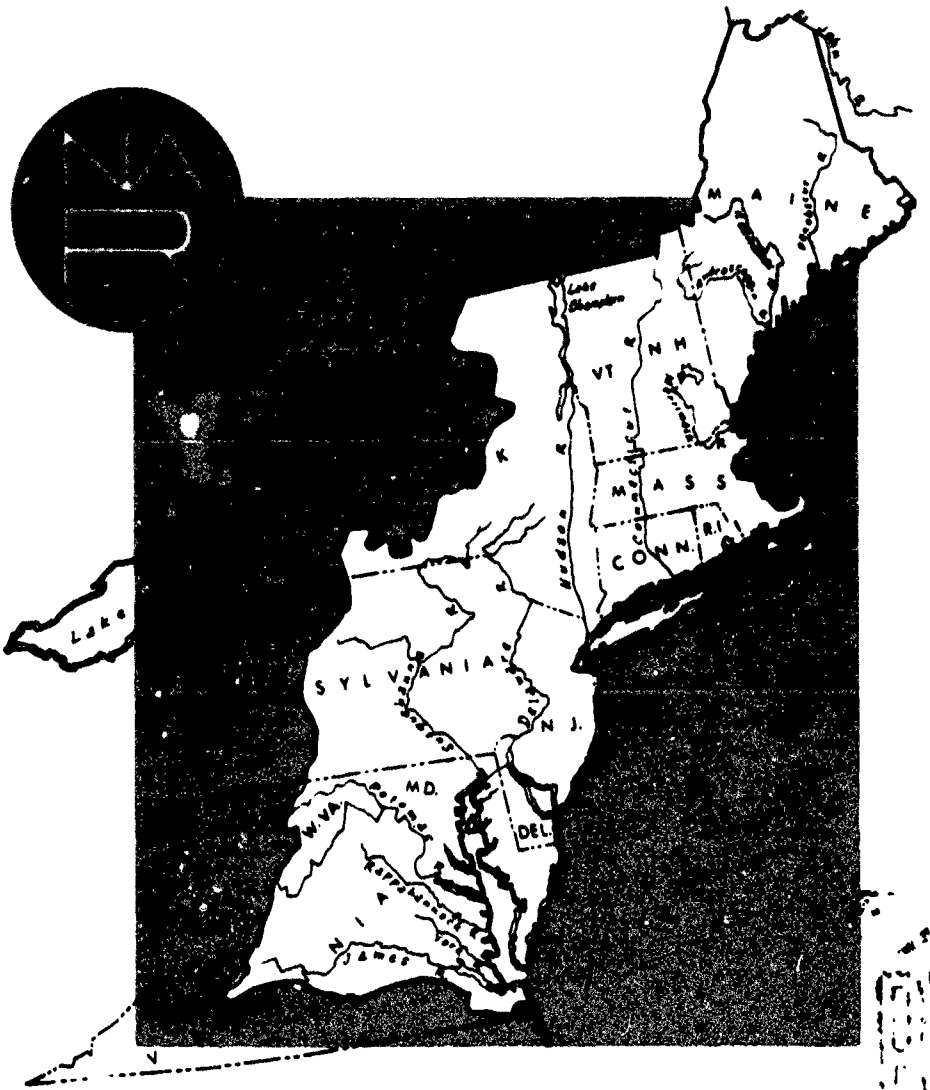
In addition to the NAR Study Main Report and Annexes, there are the following 22 Appendices:

A. History of Study
B. Economic Base
C. Climate, Meteorology and Hydrology
D. Geology and Ground Water
E. Flood Damage Reduction and Water Management for Major Rivers and Coastal Areas
F. Upstream Flood Prevention and Water Management
G. Land Use and Management
H. Minerals
I. Irrigation
J. Land Drainage
K. Navigation
L. Water Quality and Pollution
M. Outdoor Recreation
N. Visual and Cultural Environment
O. Fish and Wildlife
P. Power
Q. Erosion and Sedimentation
R. Water Supply
S. Legal and Institutional Environment
T. Plan Formulation
U. Coastal and Estuarine Areas
V. Health Aspects





Report



Prepared by

North Atlantic Regional Water Resources Study Group
North Atlantic Division
Corps of Engineers, ~~U.S. Army~~

for the

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY
COORDINATING COMMITTEE

LETTER OF TRANSMITTAL
30 JUNE 1972

Mr. W. Don Maughan
Director, Water Resources Council
1025 Vermont Avenue, N. W.
Washington, D. C. 20005

Dear Mr. Maughan:

The North Atlantic Regional Water Resources Study Coordinating Committee is pleased to advise you that the North Atlantic Regional Water Resources Study is completed and its report forwarded to you for consideration by the Water Resources Council. This report, prepared in response to Public Law 89-298 and to instructions contained in the Guidelines of June 1965, presents a comprehensive framework plan for the management of water, related land and other environmental resources in the NAR and the findings and recommendations of this Committee. The report also presents: the objectives set for water and related resources development by the Committee; includes alternative programs based on variations of objectives; and discusses some of the conflicts that may arise from resources development or protection.

The report, consisting of a Main Report with two Annexes and 22 Appendices, was prepared under the guidance of the North Atlantic Regional Water Resources Study Coordinating Committee, representing the Departments of Agriculture, Army, Commerce, Health, Education and Welfare, Housing and Urban Development, and Interior; the Environmental Protection Agency; the Federal Power Commission; the States and Commonwealths of Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia and West Virginia; the District of Columbia; and the Delaware River Basin and the New England River Basins Commissions. The preparation of this report was significantly aided by the Board of Consultants to the NAR Study whose aid freely given was invaluable.

Answers to all questions are not provided in this report. As a framework document only guideposts are presented that will lead its users to more direct routes in finding answers related to water resources management and will lead users away from or warn them of potential pitfalls. This report contains a large amount of data which is used together with stated assumptions, and many planning techniques, including computer models, to build

Mr. W. Don Maughan
Director, Water Resources Council

alternative programs. Indicated in the report are conflicts in purposes and competition for resources. The region, its problems and the possible solutions are considered in the report from the viewpoint of today's knowledge and values. Finally, all parts of this report do not represent unanimous views. Some divergent views are indicated in the report and others will undoubtedly be included in state and departmental review comments.

In accordance with the Water Resources Council guidelines, this field report will be transmitted to all study participants for their formal review. In addition, members of the Congress, the Governors of the States and Commonwealths that are part of the Study area, and the general public are being advised of the completion, submission, and availability of the report. This announcement will emphasize that the report is subject to review by Federal agencies at departmental level, by the Governors of the affected States and Commonwealths, and by the Water Resources Council prior to its transmittal to the President of the United States for his review and transmittal to Congress.

This report is the product of a partnership, one which despite many problems, divergent views and disagreements, was a successful enterprise. The professionalism and mutual respect of the participating personnel have been most gratifying.

Sincerely yours,

R. H. GROVES, Major General, USA
Department of the Army
Chairman of the North Atlantic
Regional Water Resources Study
Coordinating Committee

Richard W. Akeley
Department of Agriculture

Philip Savage
State of Maine

John Thomas
Department of Commerce

George M. McGee, Sr.
State of New Hampshire

Mr. W. Don Maughan
Director, Water Resources Council

S. William Green
Department of Housing and
Urban Development

Mark Atalson
Department of Interior

Capt William R. Riedel, USCG Ret.
Department of Transportation

Gerald M. Hansler
Environmental Protection Agency

John H. Spellman
Federal Power Commission

John E. Cerutti
State of Vermont

Charles F. Kennedy
Commonwealth of Massachusetts

Robert B. Ruse
State of Rhode Island

John J. Curry
State of Connecticut

John A. Finck
State of New York

Robert E. Cyphers
State of New Jersey

C. M. McConnell
Commonwealth of Pennsylvania

John Bryson
State of Delaware

Albert R. Miller, Jr.
State of Maryland

Edgar J. Henry
State of West Virginia

Julian M. Alexander
Commonwealth of Virginia

Paul V. Freese
District of Columbia

James F. Wright
Delaware River Basin Commission

Malcolm E. Graf
New England River Basins
Commission

SUMMARY

The Coordinating Committee of the North Atlantic Regional Water Resources Study used a multiple objective planning process to consider alternative objectives, needs, devices, benefits and costs and to develop a 50-year management program for the Region's water and related land resources. The Regional Program, and the conclusions and recommendations of the Coordinating Committee are presented in this Report with a description of the procedures and information used in deriving these results. Individual Programs for the 21 Areas of the Region are found in Annex 1 to this Report. These Area Programs have been reformulated into State Programs in Annex 2.

Physical Characteristics of The Region

The North Atlantic Region (NAR) includes the District of Columbia and all or portions of 13 states: Maine, New Hampshire, Vermont, New York, Massachusetts, Connecticut, Rhode Island, Pennsylvania, New Jersey, Delaware, Maryland, West Virginia and Virginia The NAR extends 1,000 miles from the St. John River Basin in northern Maine to the James River Basin in the southern portion of Virginia. The Region generally extends 200 miles westward from the Atlantic Ocean for its entire length and has 172,586 square miles of land and water surface, or about five percent of the Nation. For planning purposes, the Region has been divided into 21 hydrologically defined areas that range from large river basins such as the Connecticut, Hudson, Delaware, Susquehanna and Potomac, to small coastal drainages such as those of Area 13 that includes New York City and Long Island.

Social Characteristics of The Region

A 1960 NAR population of 44.7 million made up 26 percent of the United States population while generating 33 percent of the gross national product. The 1959 average per capita income of the 21 Areas ranged from $1,353 in the St. John River Basin (Area 1) in Maine, to $2,872 in the Southeastern New York Metropolitan Area (Area 13). Important economic activities of the Region are manufacturing (including the water using industries of textiles, chemicals and paper products), Federal government activities and finance and service industries.

The NAR is presently growing at a slower rate than the nation as a whole, as measured by population, employment and income. The Region's population is expected to nearly double to 86.2 million by the year 2020. The rate of growth is about 80 percent of that projected for the country as a whole, so that the NAR's share of the National total population in 2020 should decline to about 22 percent. This total population will become more predominently urban than at present and urban areas will grow in physical size. Most of this population growth will occur in the suburbs with some of these developing into new urban concentrations.

Water Resources

Surface water resources are generally abundant in the Region, but unevenly distributed in relation to the points of need. Areas with the smallest per capita quantity of developable water include Southeastern New England (Area 9), Thames and Housatonic River Basins (Area 10), Southeastern New York Metropolitan Area (Area 13), Northern New Jersey (Area 14) and Chesapeake Bay and Delmarva Peninsula Drainage (Area 18). Most of the Areas in Maine (Areas 1 through 5) have by far the largest per capita quantity of developable water in the Region while the Areas with the largest, total quantity of developable water are the Hudson River Basin (Area 12), the Delaware River Basin (Area 15) and the Susquehanna River Basin (Area 17).

Groundwater resources in the Region, for large-scale use, are abundant only in limited geologically-defined localities including the Coastal Plain, belts of sandstone and carbonate rocks; and glacial sand and gravel beds generally adjacent to rivers and large streams. Areas with the greatest practical groundwater development include the Connecticut River Basin (Area 8), the Susquehanna River Basin (Area 17) and the Potomac River Basin (Area 19).

Water Management Objectives

Three objectives were considered in this Study – Regional Development, National Income and Environmental Quality. Objective mixes for the 21 Areas were used as guides by the NAR Study Plan Formulation Work Group in choosing among program alternatives. Environmental Quality was emphasized to the greatest extent in the Region as it was given primary emphasis in the mixed objectives of 11 Areas. The other objectives each received primary emphasis in only two Areas.

The Areas with Environmental Quality emphasis have two characteristics. First, they have high quality natural resources that can be used to fulfill water recreation, visual and cultural and fish and wildlife needs. Second, these Areas are generally in close proximity to large population centers and large numbers of travelers and vacationers will be taking advantage of these resources in the future. Regional Development is emphasized primarily in Areas of high unemployment and/or low per capita income. National Income is emphasized in Areas that are expected to be able to achieve adequate economic levels through normal levels of investment.

Water Management Program

Water quality maintenance needs are the most important throughout the Region. This need will grow very rapidly and must be fulfilled in all of the 21 Areas. Areas with large water quality maintenance needs include Southeastern New England (Area 9), Southeastern New York Metropolitan Area (Area 13), Northern New Jersey (Area 14), Hudson River Basin (Area 12), Delaware River Basin (Area 15) and James River Basin (Area 21). These needs will grow most rapidly during the planning period in the Delaware River Basin (Area 15), the Rappahannock and York River Basins (Area 20) and the James River Basins (Area 21). These needs will be largest on a per capita basis in the St. John River Basin (Area 1) and the Pennobscot River Basin (Area 2).

The principal devices for fulfilling water quality maintenance needs are secondary and advanced waste treatment plants, monitoring facilities, acid mine drainage control, stormwater discharge control and separation of combined sewers. Research will be very important to enable the devices to fulfill this need. Two levels of treatment – 90 and 95 percent – will be used throughout the Region except that advanced treatment (95 percent) will not be used in Area 11. Especially large

amounts of treatment should be provided in the Southeastern New York Metropolitan Area (Area 13), Northern New Jersey (Area 14) and Delaware River Basin (Area 15).

Publicly supplied and industrial self-supplied water needs are among the most important throughout the Region. These water needs will grow as the Region's population and industrial productivity grow. The need for industrial self-supplied water will grow very rapidly, passing that of publicly supplied water during the 1980-2000 planning period.

Publicly supplied water needs will be largest throughout the planning period in Southeastern New England (Area 9), the Southeastern New York Metropolitan Area (Area 13), Northern New Jersey (Area 14) and the Delaware River Basin (Area 15). River and lake intakes are and will continue to be the most commonly used withdrawal devices for this need in the Region. Wells are becoming increasingly important throughout the NAR for this need, especially in the Delaware River Basin (Area 15). Groundwater management may become more common in the Region and will certainly be intensely sought in the Long Island portion of the Southeastern New York Metropolitan Area (Area 13), around the Pine Barrens of Coastal New Jersey (Area 16) and throughout the Susquehanna River Basin (Area 17). Transfers of water between Areas will play an increasingly important role for this need in Southeastern New England (Area 9), Hudson River Basin (Area 12), Southeastern New York Metropolitan Area (Area 13) and Northern New Jersey (Area 14).

Industrial self-supplied water needs will be largest throughout the planning period in the Connecticut River Basin (Area 8), Hudson River Basin (Area 12), Delaware River Basin (Area 15), Susquehanna River Basin (Area 17), Potomac River Basin (Area 19) and James River Basin (Area 21). River intakes will continue to be the most common withdrawal device for this need. Withdrawal intakes on brackish and saline water bodies are becoming second in quantity of use. Use of wells and of waste water intakes, while small, is growing at an increased rate.

Power plant cooling needs for fresh, brackish and saline water are large and also among the most important of the Region. Their growth rates will be high throughout the Region especially for withdrawal of saline water and consumption of fresh water. The largest power plant cooling needs for fresh water appear in the Delaware River Basin (Area 15), Susquehanna River Basin (Area 17), Potomac River Basin (Area 19) and James River Basin (Area 21). Cooling towers will be the primary means of meeting water quality temperature standards for power plants throughout the NAR. Noncondensing power generating devices that reduce or eliminate the use of steam, such as fuel cells and nuclear fusion, may be increasingly utilized.

The remaining needs of the Water Management Program are of less importance. Hydroelectric power generation is essential, however, for serving peak Regional power demands. Almost all of this need will be fulfilled by pumped storage facilities. The availability of sites primarily determines where this need is fulfilled. Irrigation water needs will grow to meet agriculture competition from locations outside the Region and to meet the increased use of golf courses and industrial parks. Sources for fulfilling this need will remain evenly divided between ground and surface waters. Effluent irrigation may become an accepted method for waste disposal and water reclamation in the Region. Rural water needs will grow although increasing quantities of rural domestic needs are being met by central publicly supplied systems. Wells will continue to be the primary source for this need. Commercial navigation and recreational boat-

ing needs will be locally important because of their impacts on local economies and environments, especially localities with good harbors and ports. Navigation channel improvements will be the primary device for meeting this need. Lightering will be of increasing importance in the Region as it helps prevent the destruction of unique shorelines.

The water resources development program for the Region includes five major devices: mainstream reservoirs, upstream reservoirs, wells, inter-Area transfers and desalting. These devices will develop new water sources for the needs of publicly supplied water, industrial self-supplied water, rural water, irrigation water and the fresh water consumption portion of power plant cooling.

Mainstream reservoirs will be the primary new sources of water in the Region. They will be the primary sources of water throughout the planning period for five Areas: Merrimack River Basin (Area 7), Connecticut River Basin (Area 8), Thames and Housatonic River Basins (Area 10), Susquehanna River Basin (Area 17) and Rappahannock and York River Basins (Area 20).

Groundwater will be the largest source of water throughout the planning period in two Areas: the Kennebec River Basin (Area 3) and the Androscoggin River Basin (Area 4).

Transfers of water between Areas will occur nine times and each transfer occurs in all planning periods. Transfers which are the largest sources of water for the receiving Areas for two or more planning periods include Southeastern New England (Area 9) receiving water from the Merrimack River Basin (Area 7), Southeastern New York Metropolitan Area (Area 13) receiving water from the Hudson River Basin (Area 12), and Chesapeake Bay and Delmarva Peninsula Drainage (Area 18) receiving water from the Susquehanna River Basin (Area 17). The last two transfers are not diversions between river basins but are large water withdrawals that could cause significant estuarine impacts.

Land Management Program

Flood damage reduction, erosion control and drainage control needs are of less importance in the Region. Much attention has been given to flood damage reduction but there are still Areas with local problems. Critical flood damage problems occur in the Passaic River Basin in Northern New Jersey (Area 14) and in New York City in Southeastern New York Metropolitan Area (Area 13). Watershed and flood plain management and upstream reservoirs will be used in combination to meet upstream flood damage reduction needs. Flood plain management will become the most extensively used device for mainstream flood damage reduction as the present local protection projects and large reservoirs are completed.

Erosion and drainage control needs will grow fairly slowly during the planning period, except for stream bank erosion control needs which grow more rapidly. Coastal shoreline erosion control needs are potentially critical, especially along those coastlines which have heavy recreation use and urban development. Land and streambank erosion protection devices should be used in all Areas throughout all planning periods. Urban erosion control needs will require special attention. Watershed management and drainage practices will be used throughout the Region in all planning periods for drainage control needs.

Environmental Management Program

Visual and cultural environment, water recreation and fish and wildlife needs are among the most impo tant of the Region. Visual and cultural environment needs are very large during the first planning period as landscapes should be preserved while costs for land purchases are relatively low. Most Areas have at least one type of visual and cultural need that is large. The northern Areas have large needs for all types of landscape maintenance and development. The large visual and cultural needs of the Region's southern Areas vary greatly between these two types. Fee simple purchases (buying), easements, tax incentive subsidies and zoning should be the devices most widely used for this need in the Region.

Water recreation and fish and wildlife man-day needs are largest in the Southeastern New York Metropolitan Area (Area 13) and Delaware River Basin (Area 15). These needs are almost as large in Southeastern New England (Area 9) and the Potomac River Basin (Area 19). Of these four Areas only the Potomac River Basin (Area 19) can supply its own needs. The other three Areas will exert pressure on the water resources of neighboring Areas.

Devices used to fulfill water recreation needs in the largest number of Areas should be the expansion of existing projects and the changing of project design loads. Other devices used for this need include overland transportation to water recreation facilities, land facilities, addition of recreation as use of an existing project, additional reservoirs, beach erosion protection and insect control.

Devices for fulfilling fish and wildlife needs in all Areas and all planning periods are fish and wildlife habitat management, the enforcement of water quality standards, land acquisition, and trails and parking. The installment of fishways and stocking of fish and small game will also be regularly used as devices for this need.

Health programs as part of water resources development are an additional need. The more important health needs are sanitary waters for recreation and shellfish, elimination of encephalitis, treatment of public water supplies and reduction of recreation disturbing mosquitoes, horse flies and biting midges. Health needs are always present so that the use of preventive devices is the best guarantee of their being fulfilled. Insect control, pollution monitoring, control of marine oil spills and swimming water monitoring are among the more widely used devices for this need.

TABLE OF CONTENTS

DETAILED TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

TABLES

CHAPTER 1

INTRODUCTION AND PROCEDURES

BACKGROUND

History and Authorization

The North Atlantic Region has changed considerably from its beginnings in the Virginia (1607) and Massachusetts (1620) settlements. Since the Region was young the demands placed on land and water resources appeared inexhaustible compared with the [illegible]

standard of living continue to increase. The concentration of population and of economic activity in the NAR has already caused certain portions of the Region to rely on distant sources of water and to allow only very expensive uses of some land. These pressures on land and water resources did not arise suddenly but developed over a long period of time.

Development in the NAR progressed inland along waterways used for transportation and power generation. Land was utilized for many purposes, primarily hunting, forestry, and agriculture, and when it was exhausted, it was abandoned. Urban and industrial land and water uses have gradually expanded and a megalopolis now exists from Boston to Washington, D. C. Much of the land and water have now been lost to anything but industrial and other specialized uses. Pollution has also increased and the capability of the NAR's water and related land resources to meet the Region's needs are becoming strained.

This situation of resource scarcity has helped to produce in the Region an awareness of the need for comprehensive planning for water and land resources. New York and Pennsylvania took the first steps with their forest preserve programs in the 1880's. The need for a more comprehensive look at water resources was not officially recognized until 1890, when Theodore Roosevelt's Inland Waterways Commission stated that plans " --- should consider and include all these uses to which streams may be put ---", but planning was still conducted on a very limited scope

While river basin planning was initiated in the 1930's, it was not until the work of the Senate Select Committee on National Water Resources of 1959-1961 that effective emphasis was placed on coordinating the various levels of government that plan and develop regional water and related land resources.

As a result of the Senate Select Committee's report (January, 1961) the Water Resources Planning Act was passed in 1965, creating the Water Resources Council and establishing machinery to coordinate the diverse interests represented by the large number of Federal, state and local agencies. The Council delineated the North Atlantic Region, one of twenty in the United States, as the subject of a regional comprehensive study of water and related resources. Congress further authorized and directed the Secretary of the Army to have the Chief of Engineers prepare a framework plan for the North Atlantic Region according to Section 208, Public Law 89-298, October 27, 1965. This law reads in part

> "The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions which include the localities specifically named in this section .....
>
> Watersheds of streams in the North Atlantic Region draining northward in New York toward the Saint Lawrence River below the international boundary and draining directly into the Atlantic Ocean above the Virginia-North Carolina state line with respect to a frame work plan for developing the water resources of the Region..."

In a letter establishing the terms of reference, the Interdepartmental Staff Committee, which was the forerunner of the Water Resources Council, directed that the NAR Study provide broad scale analyses of water and related land resource problems within the Region and furnish general appraisals of the probable nature, extent and timing of measures for their solutions. The terms of reference further proposed a Coordinating Committee chaired by the Department of the Army, Corps of Engineers, with each state, Federal agency and river basin commission in the NAR being represented.

The Departments of Agriculture, Health, Education and Welfare, and Interior, the Federal Power Commission and the Delaware River Basin Commission participated in this study with the Department of the Army, Corps of Engineers, from the outset. The Departments of Commerce and Housing and Urban Development joined the Study after the first Coordinating Committee meeting in January, 1966. The Department of Transportation, the Environmental Protection Agency and the New England River Basins Commission were added to the Coordinating Committee at a later time.

The Coordinating Committee, first organized at Newark, New Jersey, January 27, 1966, was made up of one member from each of the participating Federal agencies and river basin commissions and one member from each of the thirteen NAR states and the District of Columbia. The Committee was the guiding body providing leadership at all stages of the Study and was chaired by the Division Engineer of the North Atlantic Division, Corps of Engineers. The Corps of Engineers acted as the executive agent of the Coordinating Committee.

The Coordinating Committee met thirteen times during the Study, between January, 1966, and April, 1972. These meetings provided a forum for the discussion of problems, planning techniques and new ideas and information. The Coordinating Committee formulated Study guidelines on the basis of these discussions and Staff presentations.

A Board of Consultants was established by the Coordinating Committee in February, 1966, to provide expert advice to the members of the Committee. This Board, consisting of six eminent experts in water resources planning and development, met nine times and made significant contributions to the Study.

The planning process of the Study began in the period 1966-1967, during which time a plan of study was developed, institutional and financial arrangements were made and work packages and agency assignments were developed. The planning methods initially adopted were those used for Type II basin studies adapted to the framework type of Study.

The multiple objective approach to planning was adapted to the NAR Study during the next two years, 1968-1969. Three objectives were chosen -- National Income, Environmental Quality and Regional Development -- and three programs were developed on a preliminary basis during this first stage of plan formulation Each program stressed a different objective and consisted of alternative needs and devices and estimates of benefits and costs. A recommended program has been chosen for the Region on the basis of these programs.

Various technical methods for implementing multiple objective planning were explored at this time and those which were adopted included new data accounting systems, computer demand and supply models, and decision making procedures for choosing among the alternatives.

The final stages of the Study, 1970-1972, included the final rounds of plan formulation where decisions were made on alternative and

recommended programs. Throughout this stage planning methods were developed and used to improve the data for the alternative programs and the recommended plan.

The initial development and review of the alternative and recommended programs were carried out by members of a Plan Formulation Work Group. Each participating agency had one or more representatives on this Work Group. The Federal representatives developed data and projections for the program elements for which their agencies were responsible The Federal, state and local and river basin commission representatives then worked together to develop the initial NAR program. This program was adjusted and approved by the Coordinating Committee and appears in this Report as Regional and Area Programs.

Purpose

The purpose of the NAR Study is to develop and document the information, findings and recommendations which decision makers can use to guide the development of the Region's water and related land resources.

This framework Study provides a broad overview of the Region on both a short- and long-range basis along with accounting systems, decision processes and computer models that can be up-dated as further and more timely data become available. The NAR Study also identifies those areas and fields in which significant gaps of knowledge exist, and recommends research and study to fill those gaps.

Specifically, the NAR Study provides a set of recommendations which include regional and area development programs, identification of priorities for detailed basin and project studies, identification of priorities of needs and devices within the recommended programs, identification of research needs and recommendations for updating the Regional plan. The Recommended Programs of the NAR are not meant to present "the" answer nor the "plan" for development of water and related land resources in the NAR. The Programs provide a set of guidelines, to which water resource planners may refer, and an organized body of fact and opinion on which they may rely in making subsequent decisions in water and related resources development.

Scope

The North Atlantic Regional Water Resources Study is a multi-disciplinary study dealing with people, water and related land resources. It is a partnership effort of the Federal agencies, the states and the river basin commissions in the NAR.

Data and findings of this Study, which covers thirteen northeastern states from Virginia to Maine and the District of Columbia, are organized into twenty-one hydrologic areas that are aggregated into six sub-Regions. The planning period spans fifty years from 1970 to 2020, with intermediate benchmark years set at 1980 and 2000.

Only general levels of needs and devices are of concern in this Study. Needs, for example, are for gallons of water per day, recreation visits per day or acres of water or land surface. Devices to meet needs are presented in similar units, such as total water storage, quantities of treated water or acres of treated land.

Data and projections in the NAR Study are compiled from information in existing reports, published or unpublished; from ongoing studies, and from independent investigations. Projections of demographic and most economic parameters are based on those prepared by the Office of Business Economics and Economic Research Service (1968).

Needs were estimated only for the major purposes of water resources development such as municipal and industrial water supply, liquid waste disposal, flood control, recreation and visual and cultural requirements.

Resources were analyzed by classes such as fresh or saline water and urban or open land. Devices were chosen from available technology and were grouped by their effects on resources or on needs. Thus, the Study is comprehensive but not highly detailed.

The results of the NAR Study are presented in this Report -- which is a summary of procedures, available resources, possible alternatives and recommended regional programs; in the two Annexes to this Report - which present more detailed alternatives and recommended Programs by Areas and states; and in twenty-two appendices to this Report and their annexes -- which give complete descriptions of the Study procedures and assumptions, the resources available in the Region, and the alternatives available for planning decisions.

The Main Report and its annexes are utilized to highlight significant facts, present over-all conclusions and to state recommendations; whereas the appendices and attachments contain the complete documentation of data, methodology and sources.

PLANNING CONCEPTS

General

An attempt was made in the NAR Study to incorporate into the Federal-State planning process insights available from the development of planning theory and planning methods during the past decade. These insights generally concern the interaction of alternative development and management opportunities with the preferences of decision-makers and the public, together with the use of several new planning techniques such as systems analysis and the use of computers.

The traditional approach to planning in the water resources field has been to project future demands for the services provided by water and water related resources and to accept those projections as requirements. The projects, structural or non-structural, that led to the least cost fulfillment of the requirements constituted the plan. If alternatives were looked at, they were only alternative technical ways to fill the same requirements. It was only in the 1950's that to the question "how should a requirement be fulfilled" was added the question, "should it be fulfilled at all, or to what degree," and even later the question, "why should we develop or not develop certain resources." Objectives have now changed from expressions like, "This river needs a flow of 1000 cfs," to "the people of this basin need certain water resources investments to achieve their economic and environmental aspirations." As expressed in this Study planning is a continuing process and a plan is only the outcome of this process at one time and under one set of objectives and assumptions.

It is further recognized that just as individuals have personal conflicting objectives, each level of government may have conflicting objectives within its sphere of responsibility and authority. Conflicts may occur between levels of government as well, and often far-reaching decisions are made without adequate knowledge of the implications for the different objectives. This led to a planning effort in this Study where choices were made available between alternative planning elements -- needs, devices, benefits and costs -- based on different broad objectives.

In summary, this planning effort focuses on the process of multiple-agency planning, considers multiple objectives and multiple means, considers a range of projections, stresses flexibility and gives the decision maker various choices along with a basis for choosing among them.

Multiple Objectives

The broad objectives of planning must relate to the basic social reasons that public funds are used to develop and manage certain resources. Improvement of the quality of the environment, for example, is an objective of certain water resources planning. Other objectives include regional economic development and various types of social well-being. The choice of objectives for a particular water resources or other study depends on the desires of those whom the development and management of the resource might affect, and on the broad goals of the various levels of government involved, consistent with the level of planning being undertaken. This choice also depends on which of the desired objectives the planning activity in question is likely to affect Various types of management and development efforts are likely to have very different effects, positive or negative and significant or modest, on some objectives In the case of modest effects, it would not pay to use planning resources for detailed investigations in a study like the NAR, even if the objectives themselves were important.

Whenever an undertaking has more than one objective, conflicts will occur in the attainment of these objectives. Some sacrifice in the level of attainment of one or more objectives is required in these situations to attain the specified levels of other more desired objectives.

Alternative Planning Elements

Multiple objective planning requires that conflicts be examined by estimating beneficial and adverse effects of alternative management and design solutions on various applicable objectives. This examination illuminates the trade-offs that can be made between objectives and indicates the changes in benefits and costs that would result. Expressions of preferences from decision makers are then obtained and a further attempt is made to locate an optimal or near-optimal plan from among available alternatives.

In a framework level study, a high degree of detail is not relevant but the general multiple objective approach remains the same In such a planning effort, attempts must be made to show in general terms the types of opportunities that are available for water and related land management and development programs and the effects of these alternative opportunities on planning objectives. The resources of the planning team should be used effectively to develop as many alternatives as will contribute usefully to informed discussion on the available options.

Selection Among Alternative Planning Objectives and Elements

In a simple, one-objective planning effort the development of alternative planning elements is a technical process utilized to move toward the optimal design of the investment program. Little discussion with decision makers is required if the single objective has been clearly specified since there are no non-obvious choices involved.

When more than one objective is relevant, however, this situation no longer holds. An increase in the specificity of public preferences toward objectives becomes necessary. Such a situation requires that technical decisions be combined with decisions about objectives. Not only must alternative technical processes be developed in this situation but they must be developed in relation to alternative objectives.

The technical alternatives chosen in this situation -- needs, devices, benefits and costs -- must, therefore, relate to several objectives.

Criteria for choosing among the objectives and objective planning elements must be developed by the planning group. These criteria are based on the net benefits or returns to combinations of devices in the light of a chosen mix of objectives No matter what types of criteria are used, however, a relationship must be established between the planning group and the public as a basis of representation of public values in this decision process. This relationship may be a simple matter of the planners being representatives from organizations with legal responsibilities -- states or agencies -- or a more complex procedure of sampling public opinion on alternatives.

Relation to Other Studies

Several major studies on areas within the Region were underway concurrently with the NAR Study or were recently completed. Data and outputs from these detailed studies are incorporated to the extent that the generalized methods applicable to all Areas of the NAR could use the detailed information. This procedure sometimes causes significantly different results from those developed in the detailed studies.

Where such differences result from differences in assumptions, such as projected population or economic activity levels, these differences are shown. In general, if recommendations for the early action plans from these detailed studies fall within the limits set by the NAR framework, these recommendations should take precedence as the accepted plan over the generalized NAR recommendations. As new, more detailed river basin or project studies are initiated or old ones reviewed or updated the data, findings and recommendations of the NAR Study should serve as the point of departure.

PLANNING PROCEDURES

Incorporation of Concepts

The foregoing concepts of planning were incorporated into the NAR Study by the following steps

(1) the Coordinating Committee members were recognized as the representatives of the public for this level of planning,

(2) generalized categories of objectives were adopted by the Committee as representative of the public's diverse desires for the use of water and related land resources,

(3) objectives, needs, devices, benefits, costs and available resources were adopted as the primary elements of the planning effort,

(4) participating Federal agencies prepared the planning alternatives for those resources for which they had planning jurisdiction. Agency activities included

a. collecting data

b. participating in the establishment of assumptions to serve as the basis for alternative sets of projections of needs, devices, benefits and costs for each objective, and

c. gathering of the data, assumptions and sets of projections into Appendices.

(5) Coordinating Committee members adopted criteria for choosing a mix of objectives and alternative planning elements These criteria included

a. the objective mix for each Area should represent those values that the people in the Area will be seeking

b. alternative needs and devices should be those which will most likely achieve the mixed objective with the greatest return of net benefits to objectives.

(6) Coordinating Committee members and their staffs reviewed the sets of all alternatives prepared by the staff, adjusting them for errors, conflicts and new information,

(7) the Coordinating Committee members used the criteria to adopt a mix of objectives, needs and devices as Programs for each of the 21 Areas in the Region. These, along with the alternative planning elements and alternative programs, are presented in the Area Programs, Annex 1,

(8) the recommended Regional Program is a summary of those needs, devices, benefits and costs of the Area Programs.

Alternative Planning Elements

The foundation and first planning step of the NAR Study was the selection of alternative planning elements. Three NAR objectives were chosen - Environmental Quality, National Income, and Regional Development - to act as the guide lines by which projections were derived for alternative levels of the needs and devices, and resulting benefits and costs. Each agency responsible for a substudy made assumptions about the types and levels of needs, devices, benefits and costs which would result if one or another of the planning objectives were emphasized in an Area. Therefore, at least three levels of projections were made for most of the needs, devices, benefits and costs.

Three sets of alternative data showing the range of choices became available to the decision makers These alternatives - displayed on data sheets -- were used to guide the search for the Area Programs This display of as many of the alternatives as possible,

allowed the planners, first, to make explicit judgments about what were the best alternatives to consider and second, to give explicit reasons for choosing among those alternatives for the Recommended Programs.

The three sets of data displayed the extremes of each of the planning elements but these extremes had to be attainable in the Areas under consideration. This left the representatives the freedom to search for the alternatives that due to people's desires, seemed to be the Program that would satisfy levels of needs likely to occur.

Fifteen needs are covered in the NAR Study and include

publicly supplied water
industrial self-supplied water
rural water supply
irrigation water
power plant cooling water
hydroelectric power generation
navigation
water recreation
fish and wildlife
water quality maintenance
flood damage reduction
drainage control
erosion control
health
visual and cultural environment

Twenty-three major categories of devices are considered. Devices are any structural or managerial action which will change a resource so that it will satisfy a need or change a need so that an existing resource will suffice. The categories for devices are organized under the headings of Resource Management, Research, Education and Policy Changes and are listed on page 134.

Some costs are presented in monetary terms as first costs. Costs and benefits are also presented in non-monetary terms as descriptions of the positive and negative effects that devices and their products will have upon each other and upon an Area's physical, social and biological characteristics.

Developing the Recommendations

The decisions between alternatives was the second planning step in the NAR Study. This Plan Formulation step began with the approval and adjustment of alternatives to be sure they were realistic. This approval led to decisions between alternatives that included successively deciding for each Area upon the best mix of objectives, deciding upon the level of each need that would best achieve the mixed objective, and deciding upon the best devices to use in meeting needs.

The mixed objective for each Area was chosen because it most nearly reflected the aspirations and potential of each Area. This objective mix was then used to guide the choice of the most likely level of each need and device for each Area.

That is, the levels of needs and devices were chosen because it seemed to the Plan Formulation Work Group that they would achieve the mixed objectives with the greatest net benefits toward objectives desired by the people in the Area.

Since the non-monetary information on benefits and costs was on a descriptive basis, the participation of people very familiar with each Area -- particularly the state representatives on the Coordinating Committee -- was very critical in providing insights on such benefits and costs in addition to keeping the decision realistic.

These chosen mixes of all the planning elements were reviewed by the Coordinating Committee and adopted as the recommended Area and Regional Programs presented in this Report.

STUDY MANAGEMENT

Direction

The NAR Study was conducted according to guidelines of the Water Resources Council The initial direction enumerating these guide lines was given by a letter from the Inter departmental Staff Committee, ad hoc Water Resources Council dated June 10, 1965 This letter affirmed that the guidelines were in conformance with the provisions con templated for framework studies in the letter of December 12, 1963, from the ad hoc Water Resources Council to the Director, Bureau of Budget, which transmitted the Coordinated Planning Programs of the Council In the terms of reference, dated December, 1965, the Department of the Army, Corps of Engineers, was assigned to chair the Coordinating Committee for the Study, and was to provide over-all management services including the annual preparation of a coordinated budget for all the Federal partners in the investigation.

The Division Engineer of the North Atlantic Division (NAD), Corps of Engineers, New York City, was given a leadership assignment in a letter from the Office of the Chief of Engineers (OCE) dated 12 April 1966. Within the NAD office, an NAR Study Group was established in the Planning Division. This Study Group, and similar groups of all partner agencies, functioned as the staff of the Coordinating Committee One of the basic functions of the NAR Study Group was to prepare and monitor time schedules for all component studies and to perform other NAR Study tasks as directed by the Division Engineer.

At times special committees and task forces were utilized, the most important of which was the ad hoc Plan Formulation Work Group, which operated from 10 October 1968 to the end of the Study.

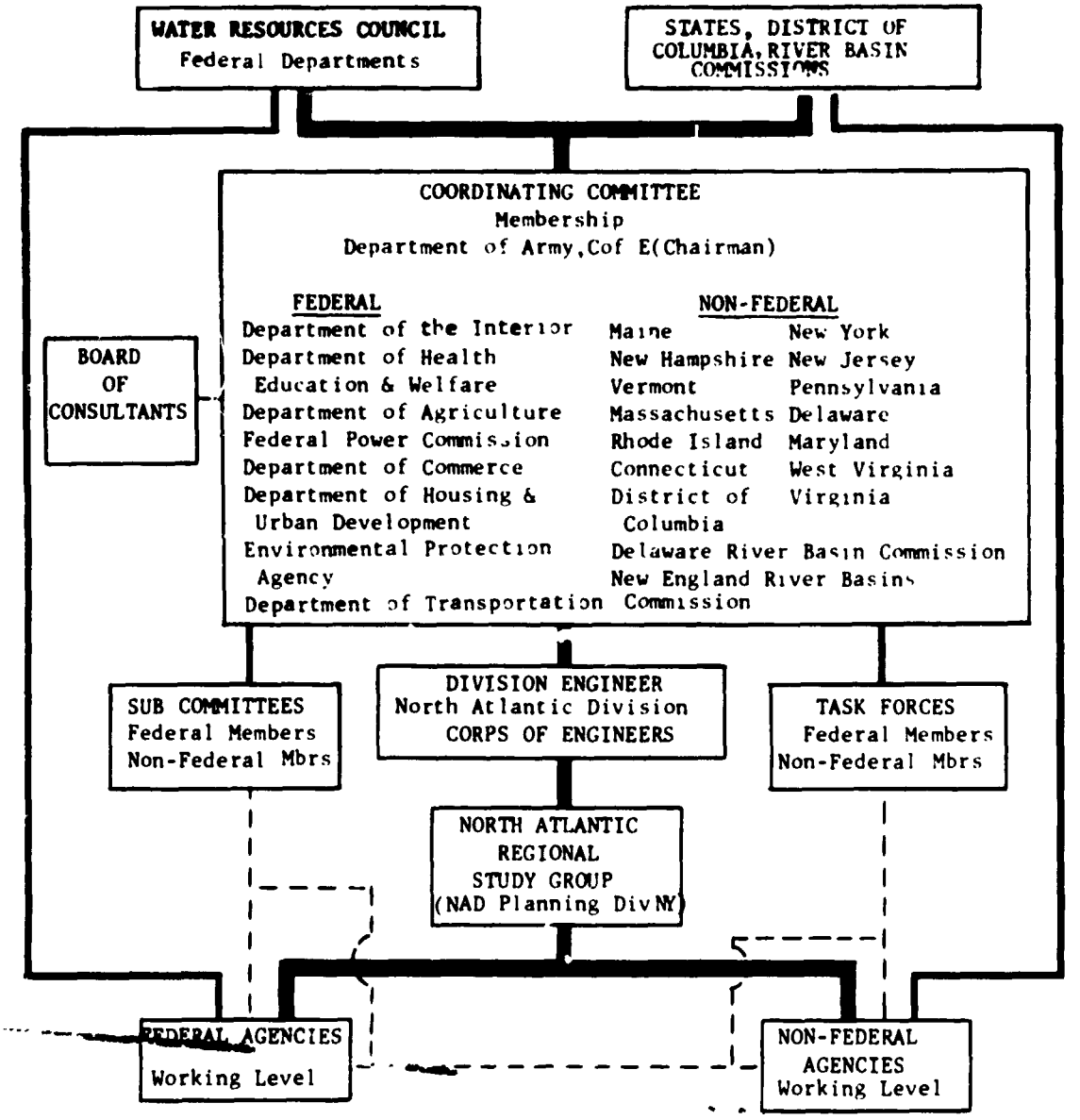
The over-all responsibility for the Study remained with the Coordinating Committee, as shown in Figure 1, which reviewed and commented upon the reports in various stages, ultimately incorporating their final views and comments in this Report

A board consisting of six eminent specialists in various disciplines connected with water resources served as advisors to the Coordinating Committee and to the Study staff This Board, established by the Coordinating Committee at its second meeting, met for the first time 26 October 1966 in New York, N. Y., and met nine times throughout the Study, as the NAR Board of Consultants

The Board members provided a broad overview as they pointed out shortcomings, suggested new or modified approaches to various problems, acted as a sounding board for ideas and brought to bear their enormous range of experience on the problems of this Study. Their actions significantly influenced the conduct of the Study for the better.

Management

The professional work of the Study was coordinated by the NAR Study Group at the Planning Division of the Corps' North Atlantic Division in New York City. The Staff of this Study Group was composed of full time professionals assisted by graduate and undergraduate students employed on a part-time basis. This staff consisted of social, physical and biological scientists, engineers, and several U. S. Army officers. The Staff worked extensively with the specialized Federal agencies in performing the professional work of the Study There was much staff contact with state agencies, principally with respect to review of professional work, enunciation of state aims and objectives and decisions on program recommendations.



MANAGERIAL RELATIONSHIPS FOR THE NAR STUDY, 1966 - 1972

CHANNELS:
- ▬ Study Management, Information, Coordination
- ▬ Organizational Control, Information, Coordination
- – – Information and Coordination

Figure 1

Coordinated budgets were prepared jointly by the Federal members of the Coordinating Committee. The day-to-day management tasks related to the Study were carried out by the NAR Study Group, with its Chief serving as Executive Secretary to the Coordinating Committee.

Coordination

Coordination between Federal and state partners in the Study, and indirectly with local bodies, was a primary function of the NAR Study Group and was carried on through the Coordinating Committee and its subcommittees, agency staffs and through Study Group staff visits.

The state representatives on the Coordinating Committee served as the contacts with local government and non-government organizations within their states. Each state and each Federal agency took the lead in those parts of the Study in which it had special competence, and each participant continually reviewed and commented on the work of all other participants and kept its own efforts in harmony and in phase with those of others This review process together with progress reports, visits, briefings, and quarterly progress reports served to keep the Water Resources Council, the Washington level of the Federal agencies, and the participating states up-to-date with the Study's progress and results.

Coordination with the public was also carried out at several levels. Coordinating Committee meetings were open to the public and were widely publicized. Mailings, brochures and press releases were also widely used. At the state and agency level each organization maintained its own contacts with constituents

Coordination between all groups involved in this comprehensive frame work study was the most important managerial task during the NAR Study and was treated as such not only by the Coordinating Committee, under which all the participants operated, but also by the individual Federal, state and local agencies themselves. It was this cooperation at all levels that made the formulation of plan recommendations possible through multiple objective planning.

Work Assignments

Special Studies and the Study appendices were assigned to specific agencies which were then responsible for their preparation. In several cases one or more agencies were assigned to contribute special inputs to a single Appendix, but one agency was always responsible for the final product.

In some instances, consultants, acting under the direction of an agency, developed major Study segments. Table I lists the subject matter of the NAR Appendices, the responsible agency and the agencies contributing specific major inputs to each Appendix.

Planning Stages

The initial phase of the NAR Study consisted of preparations for planning activities that concluded with the completion of a Plan of Study in October, 1966. This document was revised from time-to-time but guided planning activities throughout the Study.

TABLE 1
WORK ASSIGNMENTS

SUBJECT	RESPONSIBLE AGENCY	MAJOR CONTRIBUTING AGENCIES
Main Report	Corps of Engineers	All states and agencies.
Appendices		
A. History of Study	Corps	
B. Economic Base	Commerce	Agriculture, Interior, all states.
C. Climate, Meteorology, and Hydrology	Corps	Agriculture, Interior, Commerce.
D. Geology and Ground Water	Interior	All states.
E. Flood Damage Reduction and Water Management for Major Rivers and Coastal Areas	Corps	Interior, HEW, all states.
F. Upstream Flood Prevention and Water management	Agriculture	Corps, Interior, HEW, all states.
G. Land Use and Management	Agriculture	Corps, Interior, HUD, HEW all states.
H. Minerals	Interior	All states.
I. Irrigation	Agriculture	HEW.
J. Land Drainage	Corps	Agriculture, Interior, HEW.
K. Navigation	Corps	All states.
L. Water Quality and Pollution	EPA	Agriculture, Interior, HEW, Corps.
M. Outdoor Recreation	Interior	Agriculture, Corps, HEW, all states.
N. Visual and Cultural Environment	Interior	All agencies and states.
O. Fish and Wildlife	Interior	Agriculture, Corps, HEW, all states.
P. Power	FPC	Interior, Corps, all states.
Q. Erosion and Sedimentation	Agriculture	Interior, Corps, all states.
R. Water Supply	Corps	Agriculture, HEW, Interior all states.
S. Legal and Instutional Environment	Corps	All states.
T. Plan Formulation	Corps	All agencies and states.
U. Coastal and Estuarine Areas	Corps	All agencies and states.
V. Health Aspects	EPA	Corps, HEW, Agriculture, Interior.
Environmental Statement	Corps	
Public Information	Corps	

Plan Formulation in the NAR Study was based upon the assumptions and the information contained in the Study's various appendices. Each appendix contains basic data on alternative needs, supplies, devices, costs and benefits in the NAR, and represents the efforts of many previously available reports and a number of special studies, reports, field work and surveys made by or for the responsible agencies. Several problems had to be dealt with before the information was appropriate for use in the Study. One problem was the comprehensiveness of this multiple objective Study, a new concept in framework planning, and another difficulty was that much information was not available

The existing (historic) information available through agencies involved in the Study had to be reformulated into alternatives to fit the NAR's multiple objective approach. Some efforts were unsuccessful. For the most part, however, the recommendations of the Study were founded on successfully reformulated material. Changes also had to be made in ongoing and proposed studies and these changes were markedly more successful

A number of special studies were contracted for by the responsible agencies to fill in missing information. An example of the coverage of these special studies is the one for Visual and Cultural Environment, a new need stressed in the NAR Study. This study was an inventory and evaluation of environmental landscapes and cultural patterns in the NAR and a program showing alternatives for developing those landscapes and patterns

Other special studies were completed for industrial water use, urban development and land use, coastal and estuarine resources and the supply and demand models used in the Study. The latter two are important innovations which are expected to be utilized extensively in some form in future water and related resources studies. Several other general studies provided basic information on economic and water needs, on existing and developable water resources and on existing, authorized, planned or considered projects These special studies were carried out independently by the responsible agencies and then incorporated into the NAR appendices by the agencies They also play a significant part in the Study as the basis for projecting future needs and supplies and their components

NAR plan formulation activities developed into three stages after the initial Plan of Study was drawn up and approved by the Coordinating Committee. The working group for each of these planning stages consisted of the NAR Study Group Staff and the Plan Formulation Work Group representing the Coordinating Committee members The composition of the Work Group varied depending upon the type of problems and the geographical areas of concern. In the third and last planning stage, the Coordinating Committee itself became directly involved in the details of plan formulation.

In the first planning stage, September 1968 to June 1969, agencies contributing to the estimation of resource needs and supplies were asked to estimate these for the three alternative objective oriented programs The Study

Group at this stage was approaching multiple objective planning as a new technique and was exploring the abilities of the planners to work effectively with this method. Work was primarily handcrafted rather than computerized. The result of this first planning stage was a series of draft programs on supplies, needs, devices, benefits and costs for each objective and for each NAR Area

These draft programs served as a basis for the detailed development of programs in the second stage

At the second planning stage, June 1969 to September 1970, the results of one of the two computer models the demand model for projecting water withdrawals were brought into the decision making Handcrafted estimates of the non computerized program elements were, at the same time, reviewed and revised and attempts were made to effectively coordinate the various inputs

The results of both major computer models were brought into play in the third planning stage. This stage extended from September 1970 to May 1972. In the first part of this stage, the Coordinating Committee itself acted as a "task force on plan formulation" in order to consider the drafts of the recommended Area Programs for mixed objectives completed by the Plan Formulation Work Group during the second stage At this time the results of the second computer model a supply model for projecting water development were brought into the decision process The draft Programs were adjusted and approved by the task force of the Coordinating Committee and were rewritten and refined by the NAR and agency staffs At the conclusion of the third stage, the Coordinating Committee, sitting in its formal capacity, adjusted and approved these Programs as the recommended mixed objective plans for the 21 Areas and the Region

CHAPTER 2

DESCRIPTION OF THE REGION

An important starting point for planning is an analysis of the resources and other characteristics of the planning region as these are related to water resources. Inasmuch as water resources are an important segment of a region's economy and development, many aspects of a region will be related to water resources planning in some significant way. This fact accounts for the relatively wide range of the matters discussed in this chapter.

The first section of the chapter describes available physical resources and features, including those relating to topography, geology, climate, and surface and ground water. The second section describes biological features and resources, both terrestrial and aquatic. The third section describes economic and social arrangements and resources.

Boundaries

The North Atlantic Region stretches along the Atlantic Coast from the North Carolina - Virginia State boundary to the northern tip of Maine. It extends inland to encompass all of the land drainage which flows into the Atlantic Ocean through that coastal zone. All or portions of 13 states and the District of Columbia are encompassed in the Region measuring 1,000 miles along a general north-south axis and averaging 200 miles in width. The Region contains 172,586 square miles of land and water which constitute about five percent of the Nation's total area.

For study purposes, the Region has been divided into 21 Areas which, in turn, have been aggregated into six sub-regions as shown in Figure 2. The 21 Areas vary widely in size from the largest, the Susquehanna River Basin, Area 17, which covers 27,510 square miles, to the smallest of 1,900 square miles, Area 13 of New York City, Long Island and coastal Westchester County.

Some of the Areas have several drainage systems within their boundaries, expecially where the rivers are small, other Areas, such as the Susquehanna, have only one system, and still others, such as those bordering on Canada, have only a portion of a drainage system. Table 2 is supplied to identify the Areas by name, river basins and states included in each and size.

PHYSICAL

Topography

The topography of the NAR varies from mountainous terrain with elevations over 4,000 feet to flat and undulating coastal plains. Proceeding westward from the Atlantic coast the topography ranges from coastal plains through undulating hills, to rolling hills which generally have elevations of from 200 to 800 feet, to steep hills of from 800 to 2,000 feet, and finally to the Appalachian mountains in the westernmost part of the Region.

The predominant land form is rolling hills which make up more than half of the NAR's land area. Most of the Areas are made up of a little over 45 percent rolling hills, but Areas 2 and 10 have over 75 percent, while Areas 13,16 and 18 have less than 25 percent. Steep hills and mountains make up 27 percent of the Region, concentrated most heavily in Area 8 where over 60 percent of the NAR's hilly terrain is located, and in Areas 3. 4 and 6.

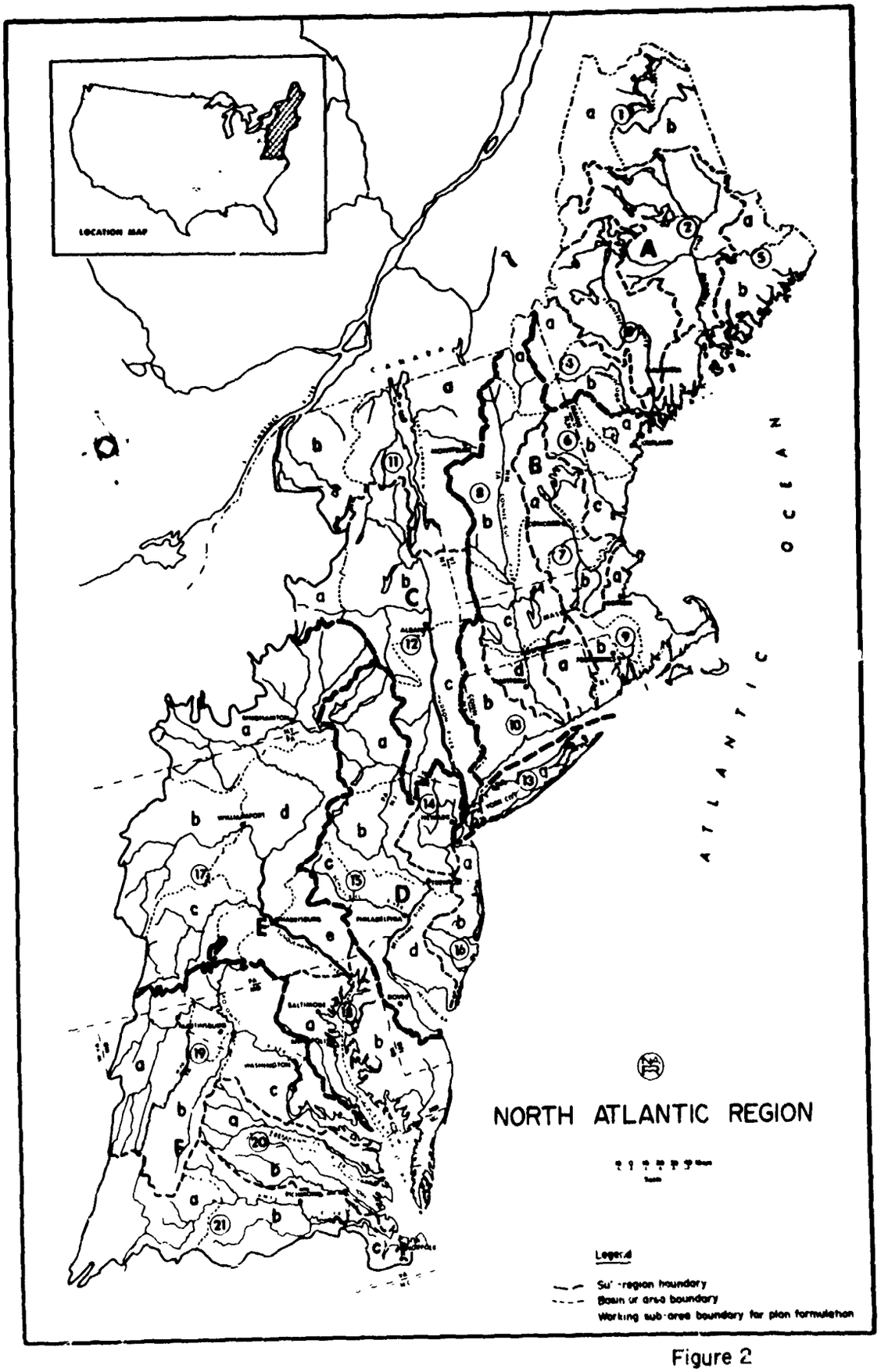

LOCATION MAP
ATLANTIC OCEAN
NORTH ATLANTIC REGION
Legend
Sub-region boundary
Basin or area boundary
Working sub-area boundary for plan formulation

Figure 2

TABLE 2
AREA DESCRIPTIONS

Area	Name	Description	Drainage Area (square miles)
1.	St. John River Basin	St. John River, Maine	11,455(1)
2.	Penobscot River Basin	Penobscot River, Maine	8,525
3.	Kennebec River Basin	Kennebec River, Maine	5,870
4.	Androscoggin River Basin	Androscoggin River, Maine and New Hampshire	3,450
5.	Maine Coastal Basins	St. Croix River, Maine; Atlantic Coastal Area from the International Boundary to Cape Small, Maine	6,856(1)
6.	Southern Maine and Coastal New Hampshire	Presumpscot River, Maine; Saco River, Maine and New Hampshire; Piscataqua River, Maine and New Hampshire; Atlantic Coastal area from Cape Small, Maine to the New Hampshire-Massachusetts state line	4,208
7.	Merrimack River Basin	Merrimack River, New Hampshire and Massachusetts	5,050
8.	Connecticut River Basin	Connecticut River, Vermont, New Hampshire, Massachusetts and Connecticut	11,250(1)
9.	Southeastern New England	Narragansett Bay Drainage, Massachusetts and Rhode Island; Pawcatuck River, Rhode Island and Connecticut; Atlantic Coastal area from southern boundary of Merrimack River Basin in Massachusetts to Rhode Island-Connecticut state line.	4,476
10.	Thames and Housatonic River Basin	Thames River, Connecticut, Massachusetts, and Rhode Island; Housatonic River, Connecticut, Massachusetts and New York; Connecticut Coastal Area.	4,555
11.	Lake Champlain and St. Lawrence River Drainage	St. Lawrence River, New York; Lake Champlain, New york and Vermont	11,900

TABLE 2 (CONTD)
AREA DESCRIPTIONS

Area	Name	Description	Drainage Area (square miles)
12.	Hudson River Basin	Hudson River, New York, Vermont and Massachusetts	13,366
13.	Southeastern New York Metropolitan Area	New York City; Long Island; Westchester County Coastal Area	1,901
14.	Northern New Jersey	Passaic River, New Jersey and New York; Raritan River, New Jersey; other Northern New Jersey streams	2,376
15.	Delaware River Basin	Delaware River and Delaware Bay, New York, New Jersey, Pennsylvania and Delaware	12,765
16.	Coastal New Jersey	Atlantic Coastal Area from Sandy Hook, New Jersey to Cape May, New Jersey	2,393
17.	Susquehanna River Basin	Susquehanna River, New York, Pennsylvania and Maryland	27,510
18.	Chesapeake Bay and Delmarva Peninsula Drainage	Patuxent River, Maryland; Nanticoke River, Maryland and Delaware; Delmarva Peninsula from Cape Henlopen, Delaware to Cape Charles, Virginia; and Chesapeake Bay Drainage from Cape Charles, Virginia to point Lookout, Maryland	8,145
19.	Potomac River Basin	Potomac River, Maryland, Virginia, West Virginia, Pennsylvania and the District of Columbia	14,670
20.	Rappahannock and York River Basins	Rappahannock River, Virginia; York River, Virginia; Chesapeake Bay Drainage from Smith Point, Virginia to Old Point Comfort, Virginia	6,000
21.	James River Basin	James River, Virginia and West Virginia; Chesapeake Bay and Atlantic Coastal Drainage from Old Point Comfort, Virginia to Virginia Beach, Virginia	10,600
	TOTAL		177,421

(1) Areas 1,5, and 8 drain 4,096, 625 and 114 square miles respectively, from Canada. These figures are included in the totals shown.

Other Areas having unusual land forms are Area 13, which is almost wholly made up of undulating land, Area 20 with three quarters of its area in undulating land, and Areas 16 and 18 which have 71 and 60 percent flatland respectively. Areas 19 and 21 are significant for their diversity, particularly Area 19 which has steep hills, rolling hills, undulating land, mixed land forms and a small mountainous area. The percentage distributions of these land forms are shown for the 21 NAR Areas in Table 3.

The NAR has several mountain ranges which have peaks of more than 4,000 feet. These peaks are in the White Mountains in Areas 4 and 6; the Green Mountains in Area 11, the Adirondacks in Areas 11 and 12, the Catskills in Areas 12 and 17, the Appalachians in Areas 17, 19 and 21, the Blue Ridge in Areas 19 and 21; and the Allegheny Mountains in Area 17. The tallest mountain in the NAR is Mount Washington (6,288 feet) in the White Mountain Chain. The Taconic Mountains in Area 8 are generally less than 3,000 feet high.

At the other end of the elevation scale are the coastal plains which extend from Long Island through Virginia with elevations ranging from sea level along the tidal streams and bays to slightly over 300 feet in southern Maryland. There are also some lowland plains along the New England seaboard and in the Mohawk River Valley in New York.

Twenty of the Areas drain towards the Atlantic Ocean, while Area 11 drains north to the St. Lawrence River. Much of the northern part of the Region was covered by glaciers which left numerous depressions that have become lakes and ponds. The combined water surface of the rivers, lakes and ponds totals about 4.3 percent of the NAR's area.

Area 9 has the largest percentage of its area in water surface (other than coastal waters) with 10.7 percent.

The following Regional map, Figure 3, shows the topographic features of the NAR.

Geology

Figure 4 shows the several physiographic provinces in the NAR. The New England, Adirondack, Piedmont and Blue Ridge provinces are underlain by crystalline and metamorphic rocks, granite, schist and gneiss, as well as quartzite and marble. In largest part, these rocks are Precambrian in age. The Triassic lowlands, underlain by sandstone, shale and minor volcanics, lie within the New England and Piedmont crystalline rock provinces. The Valley and Ridge province is underlain by highly folded and faulted layers of Paleozoic limestone, sandstone and shale. Similar rock layers are present in the Appalachian Plateau and the St. Lawrence Valley, but they are almost horizontal in attitude. Highly folded Paleozoic formations make up the Taconic Highlands. The Coastal Plain is made up of sands and clays that dip gently seaward.

TABLE 3
LAND FORM DISTRIBUTION
IN THE NAR AREAS1/

Area	Mountain	Hill	Rolling Hill	Undulating Land	Flat Land	Compound2/
			(percent)			
1	-	-	100	-	-	-
2	13	5	82	-	-	-
3	22	23	55	-	-	-
4	38	30	32	-	-	-
5	-	23	77	-	-	-
6	20	28	52	-	-	-
7	8	28	64	-	-	-
8	10	61	29	-	-	-
9	-	-	76	24	-	-
10	-	19	81	-	-	-
11	13	29	37	21	-	-
12	5	32	39	24	-	-
13	-	-	-	100	-	-
14	-	-	65	35	-	-
15	1	7	41	31	10	10
16	-	-	-	29	71	-
17	-	24	47	5	-	24
18	-	-	15	25	60	-
19	19	8	29	22	-	22
20	2	-	25	73	-	-
21	26	12	36	26	-	-
NAR	8	19	46	16	4	7

1/ Percentages do not include coastal areas

2/ Appalachian Steep and Rolling Hill

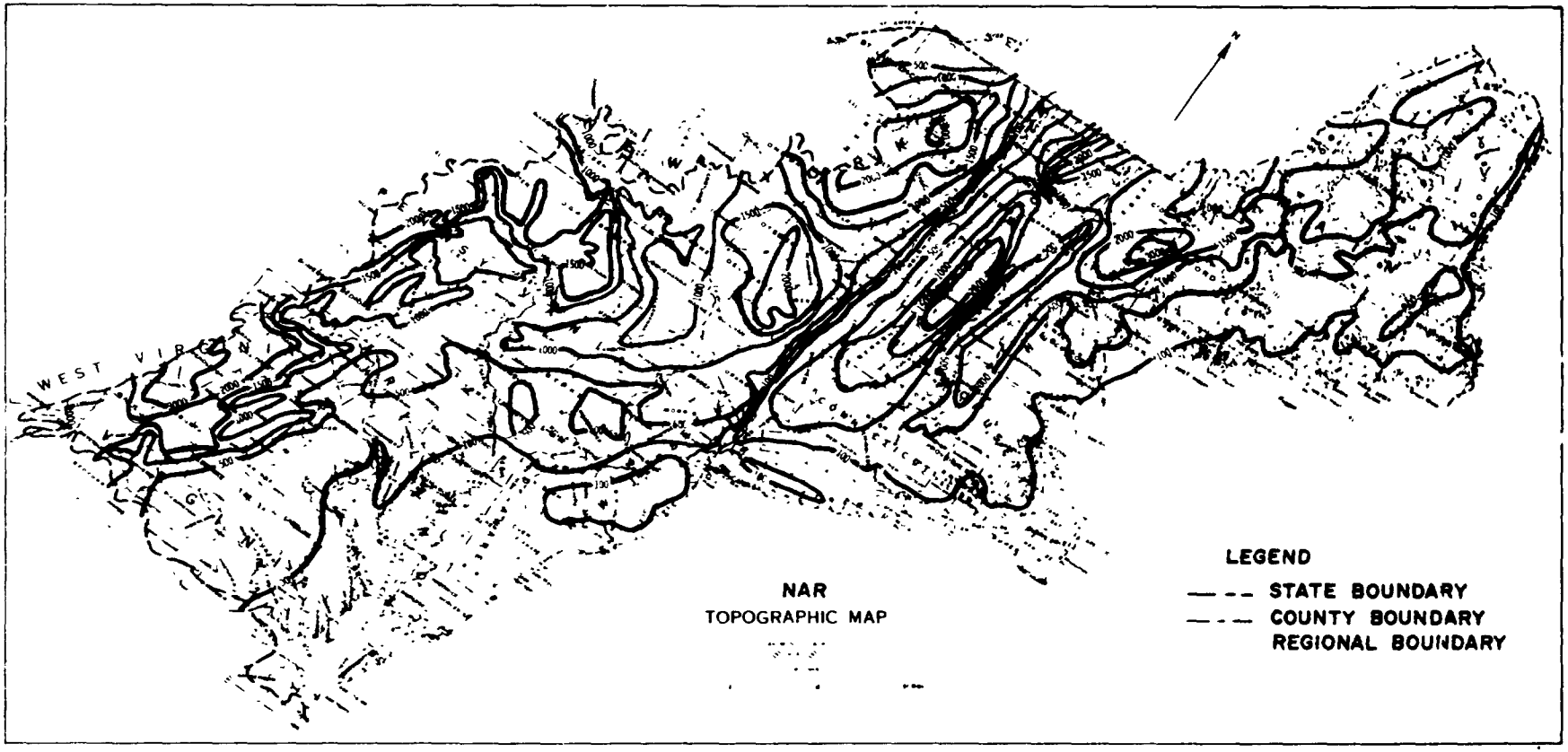

WEST VIRGINIA
NAR
TOPOGRAPHIC MAP
LEGEND
STATE BOUNDARY
COUNTY BOUNDARY
REGIONAL BOUNDARY

Figure 3

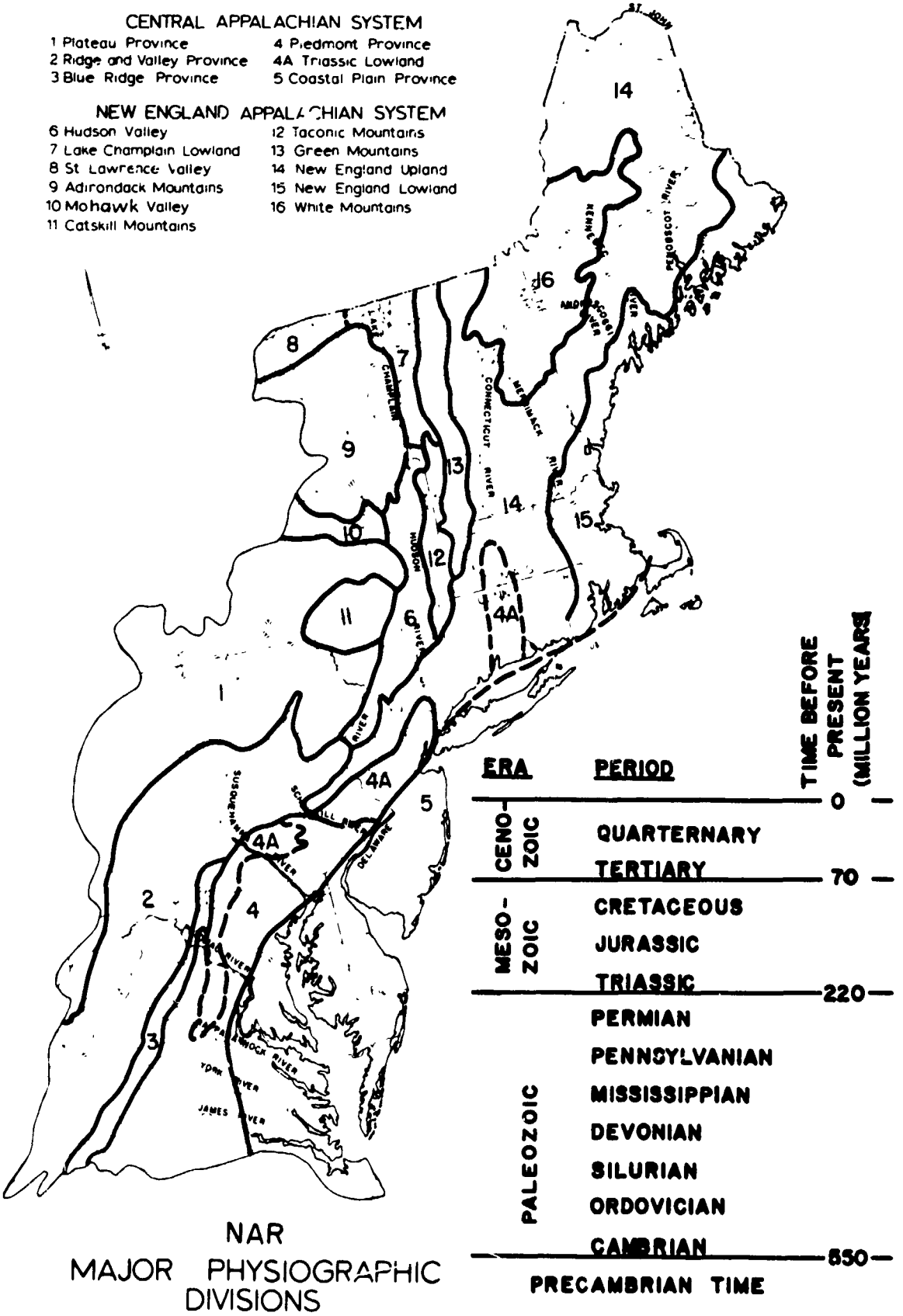


Figure 4

USDA SCS HYATTSVILLE MD 1970

The North Atlantic Region is glaciated as far south as a line drawn along southernmost Long Island and westward through Pennsylvania. The consolidated rocks in the glaciated area are masked to a greater or lesser degree by till or water laid sand and gravel deposits. Most of this glaciated area is located in the New England Appalachian System, except a small part of the Plateau Province in the west, while the rest of the NAR lies in the Central Appalachian System. The various physiographic divisions are described in more detail as follows. The Plateau Province represents the interior stable region of the continent where very gently folded strata of Paleozoic Age are dissected by an elaborate arborescent drainage system.

The Ridge and Valley Province is a folded, thrust faulted province of parallel or subparallel ridges and valleys. The topography has been formed by anticlines, synclines and thrust sheets of strata of Paleozoic Age. The rectangular drainage system of this province contrasts sharply with the arborescent drainage system of the Plateau Province.

The Blue Ridge Province is made up of Cambrian and pre-Cambrian metamorphic and igneous rocks, which are highly folded and thrust faulted toward the Ridge and Valley Province.

The Piedmont Province is an area of generally low relief underlain by chiefly metamorphosed pre-Cambrian and Paleozoic sediments and volcanics. The rocks are highly folded and faulted.

Several of the Triassic Lowlands, elongated basins of Upper Triassic sandstones, shales and diabese dikes and sills, are found in the Piedmont Province and the New England Upland. These Triassic Rocks are gently folded and faulted.

Subsequent layers of Cretaceous and Tertiary sediments of the Coastal Plain overlap the Piedmont crystallines. The sediments thicken to the southeast and crop out in bands with the oldest sediments exposed along the fall zone, a line marked by the points to which the tide extends up the estuaries.

The Hudson Valley is topographically, geographically, structurally and historically a part of the Ridge and Valley Province.

The Champlain Lowland is underlain by Paleozoic limestone, dolomite, marble, shale and slate with a few beds of quartzite. Except for the quartzite, the rocks are easily eroded and the surface is well worn down toward sea level. The bottom of Lake Champlain is below sea level.

The St. Lawrence Valley is a smooth glacial plain underlain by slightly tilted and beveled Cambrian sandstone and Ordovician limestone and shales. Relief rarely exceeds one hundred feet and occurs within the glacial drift.

A nearly circular uplift, the Adirondack Mountains are divided into a northwestern rolling upland of gentle relief and a southwestern rugged mountain mass with more than forty peaks over 4,000 feet. The Adirondacks consist mainly of pre-Cambrian rock surrounded by gently upturned Cambro-Ordovician sediments.

The Mohawk Valley is a lowland separating the Plateau Province and the Adirondack Mountains and joining the Hudson Valley with the interior lowlands. Underlain by Ordovician shales and limestones, the Valley is low and smooth only in relation to the higher and more rugged provinces to the north and south.

The Catskill Mountains are underlain by and owe their form to a nearly horizontal hard but deeply carved protective plate of coarse, porous sandstone or conglomerate. The highest summits are about 5,000 feet above sea level and local relief exceeds 3,000 feet.

The Taconic Mountains are a low range of hills composed mostly of metamorphosed, fine-grained sedimentary rocks of Cambrian and Ordovician Age. The mountains and valleys have a dominant north-south trend resulting from east-west compression.

The Green Mountains are lower in elevation than the Adirondacks which lie across the Champlain Valley. Maximum heights are above 4,000 feet but most peaks are not much above 3,000 feet. The southern part of the Green Mountains is made up of pre-Cambrian granites and gneisses. The northern part is composed of gneiss, schist, and along the eastern flank of ultrabasic intrusives and volcanics.

The New England Upland contains both wide lowland and belts of low mountains but the area is essentially a plateau-like expanse with youthful stream dissection and pronounced monadnocks. Sedimentary, metamorphic and igneous rocks mark a long and active tectonic history of the New England Upland.

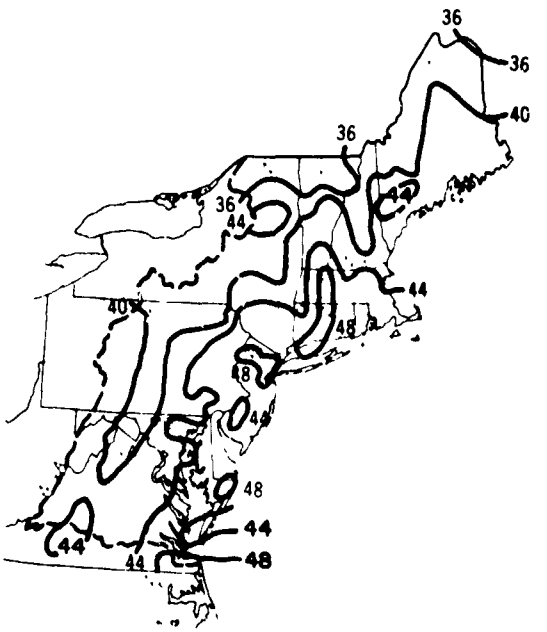
The New England lowland is essentially a sloping margin of the New England Upland that is lower and smoother than the adjacent upland.

The White Mountains are a group of scattered mountains formed by the action of water and ice on a great granitic intrusion. Elevations of hills and mountains vary upward from 1,500 feet to that of Mount Washington, 6,288 feet

Climate

There is a wide range of climatic conditions in the North Atlantic Region. The general climate of the coastal lowlands, which include the most densely populated areas in the NAR, is tempered by the proximity of the ocean. Three general types of weather patterns influence the Region cold, dry air flowing down from the Arctic, warm, moist air from the Gulf states, and cool, moist air moving in from the ocean.

The average annual precipitation in the NAR is about 41 inches, see Figure 5. The range is from less than 30 inches in northern New York State to over 70 inches in some mountainous areas, and is somewhat greater along the coast than elsewhere. The distribution of precipitation is relatively uniform throughout the year in all parts of the NAR except the coast. The coast receives greater autumn precipitation, less in winter and spring, and about the same in summer.



NAR
NORMAL ANNUAL TOTAL PRECIPITATION
(INCHES)

Figure 5

Low-pressure cyclonic systems crossing the northern part of the NAR from the Pacific Northwest, and the southern portion from the Gulf Coast, are the principal source of precipitation. Coastal storms, or "northeasters," are also heavy contributors as are the occasional hurricanes and tropical storms that move up the Atlantic seaboard. Violent thunder storms, found throughout the region, bring locally heavy rain and often hail.

Snowfall within the Region is chiefly a function of the latitude and altitude of a particular location. The average annual fall ranges from less than 10 inches in southeastern Virginia to over 100 inches in the northwest corner of the NAR, in New York.

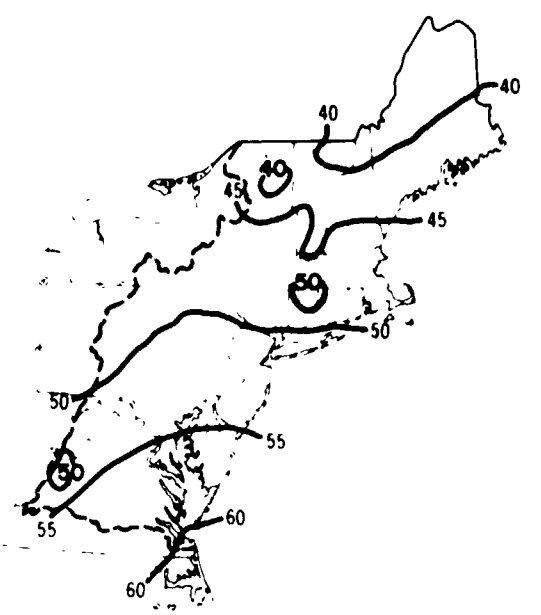
Most of the NAR is under the year-round influence of the prevailing westerlies, strongly modified by local topography. Brief wind storms, with galeforce wind gusts, are experienced in the fall, winter, and early spring, and major storms, of tropical or extra tropical origin, periodically strike the Region (especially the coastal areas) with violent winds. Tornadoes are not common and have caused only limited damage.

The average annual temperature varies considerably within the NAR, from slightly less than 40 degrees Fahrenheit in northern New England to about 60 degrees Fahrenheit in southern Virginia. Northern winters are fairly long and severe, with growing seasons averaging less than 100 frost-free days in some areas. The growing seasons in the southern portion of the Region average up to 200 days. There is also wide variation between summer and winter temperatures, as Figure 6 indicates.

Surface and Ground Water

Within the Region are such major river systems as the Connecticut, Hudson, Delaware, Susquehanna, Potomac and James. All of the surface and ground water resources of the Region combine to provide an abundant supply of water, although it is somewhat unevenly distributed geographically and degraded in quality in some locations, particularly in the metropolitan areas.

Streamflow from the Region, including the flow originating in Canada, averages about 260,000 cfs, or about 9 percent of the annual natural runoff of the United States. Since the Region represents about 5 percent of the Nation's area, the average flow on a per square mile basis is about twice the National average. The average streamflow within the NAR is about 1.5 cubic feet per second (cfs) per square mile, varying from 2.5 cubic feet per second per square mile in a few locations in New England and New York to less than 1



NAR
AVERAGE ANNUAL TEMPERATURE (°F)

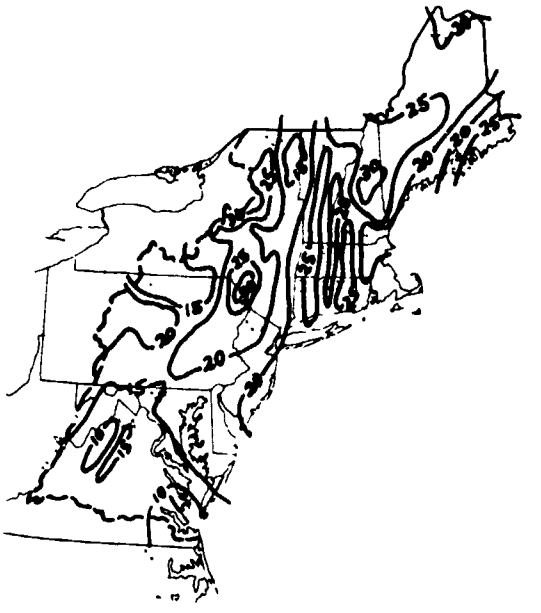
Figure 6

cfs per square mile throughout much of the Potomac, York and Rappahannock River Basins. This favorable quantity of supply is not, however, evenly distributed throughout the Region for convenient availability at locations of greatest need. The reliable use of stream flows . . . which are a combined result of surface runoff and groundwater discharge . . . is limited by large annual and seasonal variations in precipitation. The effects of these variations were demonstrated during the drought of the early 1960's.

In 1965, after several years of below average streamflow in much of the Region, many gaging stations in southern New England, New York, New Jersey and Pennsylvania recorded annual flows of 50 percent of the long term average. The flow in the Merrimack River was only 45 percent of average. The Delaware River flow was also about 45 percent of average, and because of the large demands of the metropolitan areas serviced by this River the effects of the drought were severely felt in this area. Streamflows in the Susquehanna and Potomac River basins in Virginia were on the order of 60 percent of average.

Extended periods of low flow, such as occur during droughts, are rather infrequent in the NAR and seasonal variations play a more immediate role in many water problems of the Region.

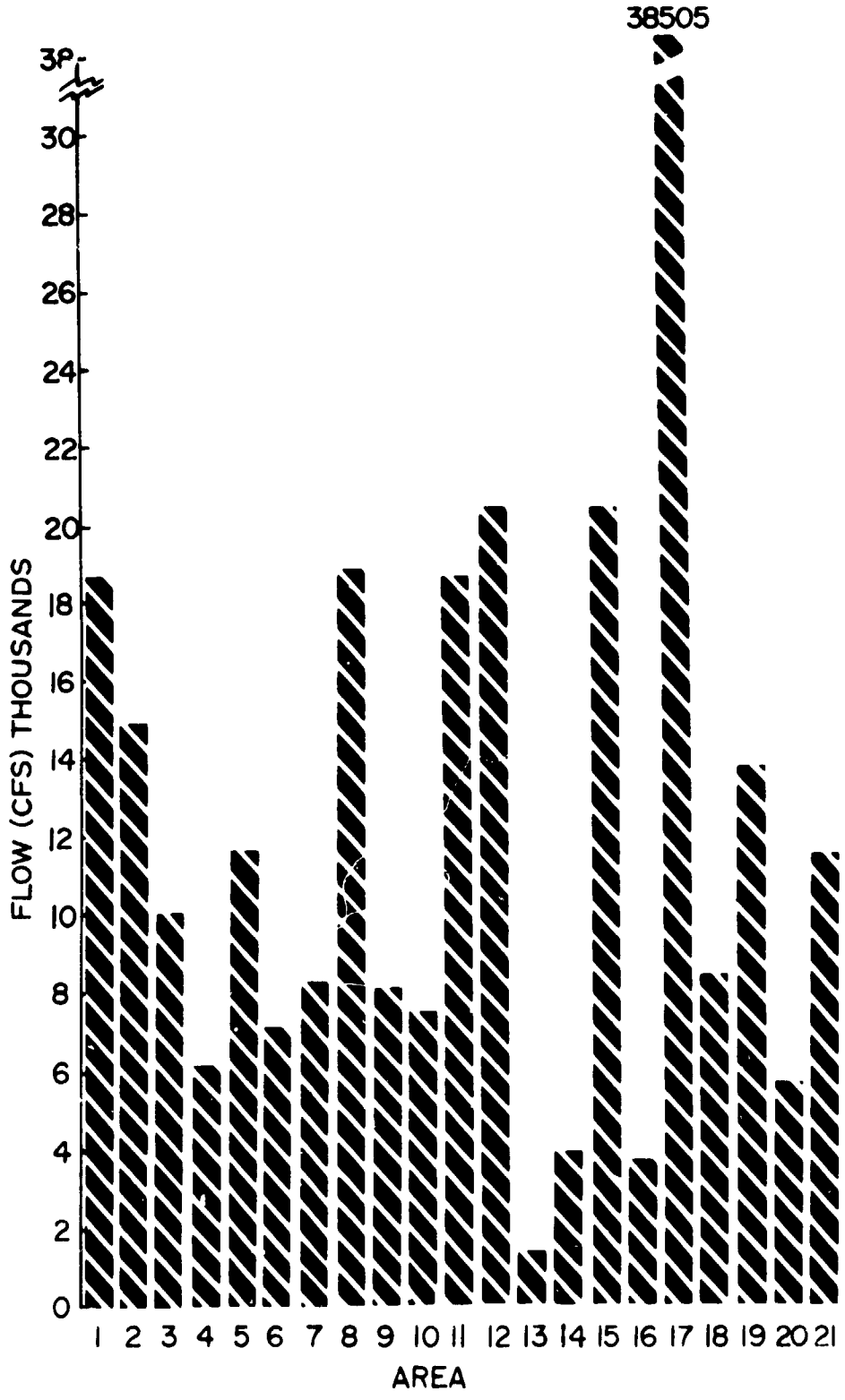
In most parts of the NAR, more than half the annual runoff occurs in a three month period, generally in late winter and early spring in the northern, and somewhat earlier in the southern part of the Region. The months of lowest runoff are generally the same throughout the Region and occur between June and October, with August and September as the months with predominantly the lowest runoff. Average annual runoff in inches and average streamflow in cfs for the 21 Areas is shown in Figures 7 and 8



NAR
AVERAGE ANNUAL RUNOFF
Inches

Figure 7

Too much water from excessive rainfall, snowmelt, ice-jams and high tides have caused heavy flooding every few years at one or more places within the NAR. The most damaging floods result from hurricanes or the combination of heavy spring rainfall and snowmelt. Flooding can occur at any time of the year, but spring and fall are, for the reasons cited, generally the seasons of most frequent flooding. The northern part of the Region, particularly in New England, contains relatively large amounts of natural storage which have a mitigating effect on flood peaks along major streams. Flow variations are more severe in the southern portion, where ratios of 600 to 1 between high and low flows are not uncommon in some places.



AVERAGE ANNUAL STREAMFLOW, NAR

Figure 8

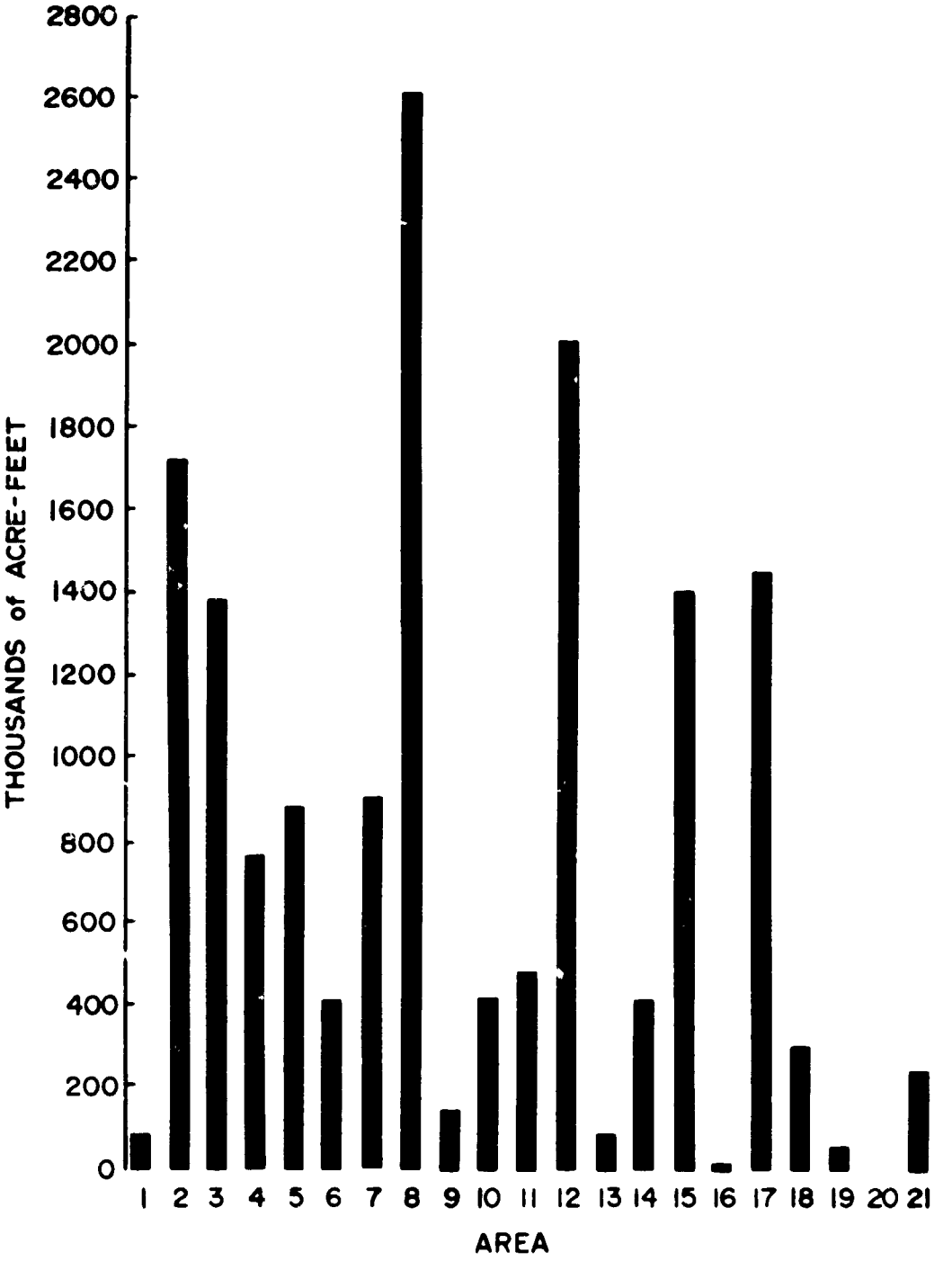
Existing streamflow in the NAR, including flows into the Region from Canada, is more than 170,000 cfs and this is available about 95 percent of the time. This is the amount available, on the average, in 19 years out of any twenty-year period. For purposes of hydrologic analysis, this flow could be used as a practical degree of development. This does not consider carry-over storage from year to year, which it would be necessary to do in using a development figure close to average flow.

About 44 percent of this, or more than 75,000 cfs, is available in New England (Areas 1 through 10) where net evapotranspiration losses are low and many natural lakes combine to produce very favorable runoff conditions throughout a wide area. This value is about 48,400 cfs in the Hudson, St. Lawrence and Delaware River drainage Areas (Areas 11 through 16) and about 46,800 cfs in the basins draining into Chesapeake Bay (Areas 17 through 21).

There are almost 16 million acre-feet (maf) of existing usable storage in reservoirs with volumes larger than 5,000 acre feet. This reservoir storage is shown in Figure 9 for each Area. Areas 1 through 5, in northern New England, together contain the largest amount of this large size storage with about 4.8 maf and Areas 19, 20 and 21 together contain the lowest amount of this storage, with less than 0.5 maf. Much of the storage in the northern part of the Region is used for power, while storage in the central and southern portions is used relatively more for flood control and municipal supply. Additional storage is available in this Region in numerous smaller upstream reservoirs. The releases from reservoirs in many basins of the northern part of the Region have a significant effect on dry weather flow, reducing stream flow variations considerably. The ratio between average and monthly minimum flow in the Androscoggin River Basin, for example, is about 2.8 in portions of the Area where no regulation exists, and 1.9 where stream flow is regulated. In the Penobscot River Basin this effect is more significant, with a ratio of about 3 to 1 for the total Area, and a ratio of more than 100 to 1 on smaller unregulated tributaries.

Surface water accounts for about 4 percent of the total land and water area of the Region. Approximately 90 percent of these water surfaces have 40 or more acres of surface. This figure includes natural and artificial lakes, ponds, streams, estuaries and canals one-eighth of a mile wide or greater, and deeply indented embayments, sounds and other sheltered coastal waters, protected by headlands or islands. Half of this water surface, nearly 3,300 square miles, lies in Areas 1 through 10 in New England.

The overall quality of surface water covers the entire spectrum in the Region and varies widely with location, being generally poorer at times of low flow. The State of Maine has an overall high quality of surface water, characterized by a low to moderate mineral content and hardness, and industrial and sanitary waste is comparatively low in the fresh waters of Areas 1 through 4. The greater population and more concentrated industrial areas in southern New England create man-made problems although the natural chemical quality is good and sediment concentrations are low.



EXISTING* RESERVOIR STORAGE, NAR

*Includes projects of 5,000 or more acre feet of usable storage completed or under construction as of [illegible], 1963. Major projects completed since this date include Round Valley Spruce Run in Area 1, Cannonsville in Area [illegible], Lake Raystown in Area [illegible] and Gathright Lake in Area 2.

Figure 9

The waters of the Hudson and Delaware Rivers and some basins draining into the St. Lawrence River are generally soft to moderately hard and dissolved solids concentrations range from low to intermediate. The estuarine waters in Areas 11 through 16 range from poor to completely unusable for most purposes. Dissolved solids concentrations are high in Areas 17 and 18 where coal mining has caused extensive pollution from acid water drainage. The waters of the southern portions of Areas 17 and 18 are particularly subject to salinity intrusion. In Areas 19, 20 and 21 sediment and dissolved solids concentrations are low to moderate and waters are soft except in mountainous areas.

Ground water is in over all abundant supply with available rates of flow of up to several tens of millions of gallons per day in some well fields in the coastal plain, in sandstone and carbonate rocks, and in glacial sands and gravel beds in the more northerly areas. Smaller quantities of ground water are available throughout the Region in places underlain by crystalline rock and shales, with yields limited to about 1 mgd per well field.

Ground water development in 1965 amounted to about 2,560 mgd, with about 45 percent used for municipal supply, 15 percent for rural domestic supply, 34 percent for self supplied industrial use, about 3.5 percent for irrigation and the remainder for electric power and livestock. New York State is the largest user with about 600 mgd more than half of which is used on Long Island. New Jersey is the next highest user having withdrawals of about 530 mgd.

Ground water quality on an over-all Regional basis is good. Hardness is encountered in carbonate rock and iron or manganese are found in undesirable quantities in glacial deposits. Wells in coastal plain sediments near the sea may yield water that is high in chloride content, limiting its use.

Water losses through evapotranspiration are a function principally of water availability, heat supply and vegetative covering, all of which are at or near their maximum during the growing season. Most evapotranspirative losses, therefore, take place between April and October in the Region. The annual evapotranspiration is least in Areas 1 to 5 where average temperatures are lowest and the growing season is shortest, while losses increase southward being greatest in Areas 19 to 21. In New England, annual evapotranspiration is about 18 to 20 inches. In the St. Lawrence, Hudson and Delaware river drainages in the NAR it varies from about 20 to 25 inches and in the Chesapeake Bay drainage basins it ranges from about 24.5 to 28.5 inches. About 25 percent or more of the total annual evapotranspiration occurs in July.

The net losses from reservoir surfaces are from 4 to about 7 inches in the northern half and from 8 to about 9 inches in the southern half of the Region.

BIOLOGICAL

The North Atlantic Region is of particular economic and cultural importance to the United States because of its rich base of natural resources. The Region's agricultural and industrial development began in and around the biologically productive estuaries and progressed inland along waterways, passing through successive regions of distinct physiography, climate and identifiable biologic communities. These diverse environments played a significant role in shaping man's activities in the NAR.

Estuarine-coastal and terrestrial-river are the two most easily discernible environment classifications in the Region. It is more useful, however, to apply a more detailed classification scale to the various environments in the NAR. This approach will give a better indication of the effects that subtle differences in sub-environments have had on man's way of life and on the interactions of his activities with his habitat.

Terrestrial

Distribution of forest types, the dominant plant species in the NAR, has been primarily influenced by climate. Local differences in plant types relate also to local drainage patterns and soil substrate differences. The only clear correlation between a physiographic delineation and a forest type in the NAR has been on the Coastal Plain where the yellow pine-hardwood forest is constrained in the NAR to the Plain's sandy substrate.

Forests of the NAR cover 66 percent of the land area and 96 percent of this forest is classified commercial. Five major forest types in the Region are:

1. Coniferous forest (spruce-fir)-- located primarily in Maine with smaller sections in New York, Vermont and New Hampshire.

2. Northeastern Pine (white and red pine, hemlock, hardwood) -- stretches across the central NAR through Pennsylvania, New York, Connecticut, Rhode Island, Massachusetts and into significant portions of New Hampshire and Maine.

3. Northern Hardwood (beech, birch, maple)-- begins in northern Pennsylvania, and stretches through most of New York and Vermont, reaching into New Hampshire and Maine.

4. Southern Hardwood (oak, hickory, yellow poplar)-- the largest forest type in the NAR, covers about one third of the Region principally in Virginia, Pennsylvania, Maryland, and New Jersey with significant amounts also in southern New York and Connecticut.

5. Coastal Plain Hardwood (yellow pine, hardwood)-- the smallest of the five main forest types, confined to coastal sections of the Region in Virginia, Delaware, Maryland, New Jersey, eastern Long Island and the eastern tip of Massachusetts.

Within each forest type the species cited predominate, but in general, the northern NAR is dominated by soft wood species such as white pine, spruce and hemlock. The central NAR and the southern upland are noted for an abundance of hardwoods- oaks, yellow poplar and the valuable black cherry and black walnut. Loblolly pine and the other typically southern pine species dominate in the southern coastal sections.

The natural variety of forest in the NAR, plus the many types and degrees of past use, have resulted in forests that presently vary greatly in appearance, age, size, condition, stocking and value. Only a few thousand acres of virgin forest remain in the NAR, most of the forests having been cut over from one to six times. One sixth of the forest area is growing on land originally cleared for farming but subsequently abandoned.

The NAR was once fully forested but today only about 66 percent of its land area is classed as forested and only 60 percent of this is fully covered by trees. Along the coast and in the river valleys extensive acres of cropland and great metropolitan or urban areas have replaced the forest. One result of the decrease in forest is that in spite of intensive hunting, deer have increased in numbers from colonial times because they prefer terrain of the early succession stages of forests that are made up of grassy meadows, shrubs and small trees.

The forest types mentioned above contain many other species of woody and herbaceous plants of ecological importance. These plants exist in close association in the NAR because of similar requirements as to soil, light, moisture and temperature.

The oak hardwood forest type usually has an understory composed of dogwoods, sassafras, witch hazel, and huckleberries. Beneath this under story are herbaceous plants including hepaticas, bloodroot, wild geranium and meadow rue.

The tree species in the northern hardwood forest type occur in varied proportions according to climate and soil. Beneath the understory of young trees of the dominant species and where sufficient light can penetrate, can be found violets, trilliums, dutchman's breeches and wild ginger. Ferns take their place wherever there is deep shade and waxy Indian pipes and brown beech drops are found in the darkest spots.

An interesting plant association may be found throughout the NAR in the form of the Hemlock Ravine. This association is found where topography discouraged attempts at timber cutting and remnants of the first or second growth may be found. Beneath the Hemlock is an understory composed almost entirely of smaller hemlock of all ages and of even smaller plants such as mountain laurel, Rhododendron, Viburnum alnifolium, solomon's seal, bellworts, bishop's caps and ferns and mosses.

Each uncultivated field or meadow is a natural garden covered over with large numbers of many different species. They are controlled, however, by varying conditions of soil and moisture. Some are found only on rocky outcrops and in thin soil: some in rich well-drained areas and some in moist places. In any sizable acreage these situations adjoin one another and their characteristic vegetation becomes intermingled. Some of these field plants are well known and used in gardens, some are varieties introduced into gardens from Europe that have become naturalized. The Ox-eye daisy, chicory and wild carrot are examples of such imports. Native plants to be found in fields in the Region include such species as milkweeds, flags, golden-rods, asters, monardia, buttercups, butterfly weed, boneset and evening primrose in combination with all types of grasses.

Abandoned farms found in the New England portions of the Region illustrate what happens to an environment, within a generation or two, when nature is left to run its course. The once cultivated fields are soon covered with shrubs and herbs, then junipers which are quickly followed by gray birches and then pines.

Closely associated with the open field plant situation in the NAR, in many instances, is the hedgerow. This is a comparatively narrow, natural or planted strip which the farmer did not encroach on in clearing for his fields. Its edges are usually straight and well ordered. Some of its spontaneity is due to the varying ages of the plants, for seedling growth is constantly springing up around more matured vegetation. Choke cherries and pin cherries are almost always found in these areas. Blackhaw viburnum also abounds in hedgerows. In wetter places are hazelnuts, arrowwood, spirea and potentilla. In addition, smaller trees like the wild black cherry and hawthorn contribute an irregularity to the skyline of the hedge row. This variation is further accented by vines such as honeysuckles, Virginia creepers and fox grapes that form tangled masses and even climb into shrubs and trees.

The North Atlantic Region, by virtue of its considerable physical and climatic variety, provides habitat for a large number of fish and wildlife species interactive with human and plant communities. The extensive forests of the NAR provide habitat for large animals such as whitetailed deer, black bear and moose, and for small species, including ruffed grouse, gray squirrel, snowshoe hare and wild turkey. These and many other animals are found throughout the Region, except for moose, which are limited almost entirely to the Maine wilderness: snowshoe hare, found only in isolated pockets in the northern part of the Region: and wild turkey, rescued from near extinction and found in the western portion of the NAR. Fur animals are found throughout the Region.

Deer are the most abundant large animals in the Region. Deer habitats include woodland, forest-edge land, thickets along streams and farm land. Black bear roam the same habitat but are numerous only in a few isolated areas.

Small game animals are of two broad classes, forest game and farm game. Forest game includes ruffed grouse and gray squirrel, which occupy the same habitat as deer and black bear, and varying types of hare and turkeys. Hares are not as widely distributed as squirrel and grouse in the Region, as they prefer swampy areas with dense stands of conifers and are located primarily in pockets in the northern third of the Region.

Farmland small game animals like the cottontail rabbit and bobwhite quail are widespread in the Region. The pheasant, which shares this habitat, is not native to the area and must be artifically restocked in order to thrive. The bobwhite quail thrives in agricultural areas of diversified farming. Their habitat is limited to the areas south and west of Cape Cod because they cannot survive severe winters. Cottontail rabbits prefer relatively warm and dry climates and are found in the western and southern three-fifths of the NAR.

Migratory waterfowl, including the Canada goose, brant, black duck, redhead, scaup, canvasback, teal, woodduck, and mallard, nest in the northern NAR and Canada in open sheltered coastal and inland waters. The many inland waterways, ponds and lakes and the inlets, bays, and harbors of the Atlantic coast provide excellent habitat for these species. Woodcock and mourning dove, also migratory, are distributed throughout the Region, with the woodcock being more abundant in the north and the mourning dove more plentiful in the south and west.

Special mention must be made of the six species of wildlife in the NAR that are considered rare or endangered, because of disease, over-exploitation, or loss of habitat. These include the southeastern pine grosbeak (peripheral), northern bald eagle, southern bald eagle, ipswich sparrow, beach meadow vole, Block Island meadow vole, and peninsula fox squirrel.

Aquatic

The fresh-water aquatic habitats within the Region, although they constitute only a small percentage of the Region's surface area, are nevertheless an important focal point for natural resources. The NAR's diverse types of aquatic habitats are high on the biological productivity scale, and within each system exist habitats of varying combinations of optimal physical factors to which biological communities adapt. There are numerous streams, lakes, ponds, swamps and bogs, all of which provide habitats for many types of organisms and interact in a vital way with the rest of the environment.

The rivers and streams of the NAR are distinguished by longitudinal successions of community types which have adapted to the two primary limiting factors: speed of current and temperature. Most of the Region's longer rivers originate in the higher elevations of the Appalachian mountain system. At their sources, these streams are characterized by swift, turbulent flows of relatively cold water. The benthic or bottom dwelling plants and animals are sparse because swift currents keep the hard substrate clean. The faunal community is composed of a few dominant species such as trout, darters and minnows, snails and crayfish.

With increasing distance from the source stream gradients and current velocities decrease, channels widen and water temperatures usually increase. The bottom substrata become softer and more varied with a gradation of sediment size down stream as the decrease in stream velocity causes much of the sediment in suspension to drop. If all other physical factors are constant, the nature of the substratum becomes the controlling factor in the distribution of plant and animal communities. The lower reaches of these NAR streams, with a substrate of fine sand, mud and particulate organic detritus, support communities of filter-feeders composed of burrowing worms, molluscs, carp, suckers and catfish.

The ever-present supply of water and the moisture laden atmosphere make the stream and river environments ideal for many kinds of trees, shrubs and numerous herbaceous plants. Elms sometime define the course of a stream, sycamores grow singly along the banks and willows arrange themselves in almost regular rows along the margins. Among the shrubby vegetation there can be found sweet gale, dogwoods, elder, witch hazel and alder. This varied vegetation, together with myriad herbaceous plants and ferns, is found everywhere in the NAR.

Ponds produce a vegetation that is commonly composed of those types of plants that thrive in quiet water and full sunlight. Among the kinds of native aquatics found in the Region are water lilies, arrowheads, sweet flags, pickerel-weeds, reeds, sedges, rushes and cattails. Unfortunately, in certain circumstances these plants have to be kept in check because they are active agents in the eutrophication process.

Bogs in the true sense are comparatively rare phenomena and are scattered throughout the Region. A true bog is a poorly drained, waterlogged area, the water being definitely acid and containing plants tolerant of the situation. Some of these plants can not be found in any other place. Plants in bogs are found in a series of concentric zones. In the center there is often a pool of water surrounded by sphagnum moss, followed in an outward direction by cranberries, sundews, pitcherplants, sheep laurel, bog rosemaries, alders and larch.

Salt marshes in the NAR begin their formation when the physical forces of the sea interact with the sediment laden rivers and streams to deposit fine grained sediments in the bays and estuaries and continuously shape and rearrange their forms. As the shallow waters fill with silt, the resulting mud flats are colonized by salt water grasses. Beginning with cordgrass, peat is built up and seaside plantain, salt-marsh bulrush, glasswort, sea lavender, aster and goldenrod appear.

The natural vegetation along the edges of the ocean, whether on sand bars or on rocky shorelines, is adapated to cope with barren soil and excessive dryness. Plants in this habitat are often storm tossed, gale bent and weather gnarled. Here are found pines, oaks, bayberry, beach plums, sand myrtles, juniper, bear berries and beach roses. Among the first to stabilize dunes are beach grass, panic grass and beard grass.

The coastal-estuarine zone is the most productive of the NAR aquatic environments, although subject to more natural stresses than any of the other environments of a similar size. The zone is affected by tides, ocean waves and storm surges; by winds, daily changes in salinity, and seasonal variations in river runoff and nutrients; and by thermal stratification and oxygen depletion.

Yet, in spite of this zone's apparently hostile environment, the estuaries support by far the bulk of the NAR's commercial shellfish. In addition, an estimated two thirds of all commercial fish species harvested in the Atlantic Ocean waters of the NAR spend part of their life cycle in estuaries.

The NAR contains several broad semi-enclosed estuaries such as the Chesapeake and Delaware Bays. There are many smaller coastal-estuarine environments, from the highly indented coastline of Maine to the lagoons and barrier beach-bays of the Delmarva Peninsula.

Fishery resources are of three general types in the NAR: fresh water, salt water, and anadromous. Fresh water fish are of both cold-water and warm-water species. There are 2.4 million acres of fresh water streams, lakes and impoundments in the NAR and there are many species in these waters. The more abundant varieties include: land locked salmon, brook trout, lake trout and smelt, which are indigenous to the Region; brown trout which was introduced from Europe; and rainbow trout, imported from the Rocky Mountains. Brook trout are widely distributed in small cold-water tributaries, and the brown and rainbow trouts are even more widely distributed as they are better adapted to slightly warmer and larger streams. Land locked salmon and lake trout, both of which are in short supply, inhabit the larger cold-water lakes, and some of the rivers in the vicinity of those lakes, primarily in Maine, but also to a lesser extent in New Hampshire, Massachusetts, Vermont and New York.

The smelt is actually a salt-water fish, but it easily establishes land locked populations and is often used in lakes to provide forage for land locked salmon.

Warm-water species of the NAR include small- and large-mouth bass, northern pike, catfish, walleye, white perch, chain pickerel, muskellunge and various types of panfish. Habitats and, thus, resources for these fish are more numerous in the more southern, warmer reaches of the Region; but these species are also found to some extent in cooler waters.

Anadromous fish are spawned in fresh water, migrate to the sea, grow to maturity, and return to fresh water. Regionally important species include striped bass, American shad, white perch, smelt, alewives, blueback herring, Atlantic salmon and sea-run trout.

Historically, almost every river of the NAR draining into the ocean had large anadromous fish runs, but pollution, over fishing, construction of dams, low flows, and like causes have greatly decreased them, and those runs of significance are limited to just a few rivers such as those draining into the Chesapeake Bay. Cooperative efforts of the U. S. Fish and Wildlife Service, the states and the National Oceanic and Atmospheric Administration are seeking to restore the Atlantic salmon and other anadromous species.

There is a large variety of salt-water fish along the coast of the Region. The principal species include flounder and fluke, bluefish, striped bass, porgy, and blackfish.

A number of aquatic species in the Region are also rare or endangered. These include the bay turtle, Atlantic salmon, Atlantic right-whale, Atlantic sturgeon, blueback trout, Sunapee trout, short nose sturgeon, pine barrens tree frog and Maryland darter.

In its natural state, the NAR is biologically one of the most productive areas in the United States. Ironically, it is this original wealth of natural resources, of swift streams and inviting harbors, which is endangering the viability of the numerous interdependent habitats and natural environments. These resources are highly attractive to man's development. The extent of habitat disruption, or destruction, brought about by man's development of the NAR's resources, largely through indirect relationships, is uncertain.

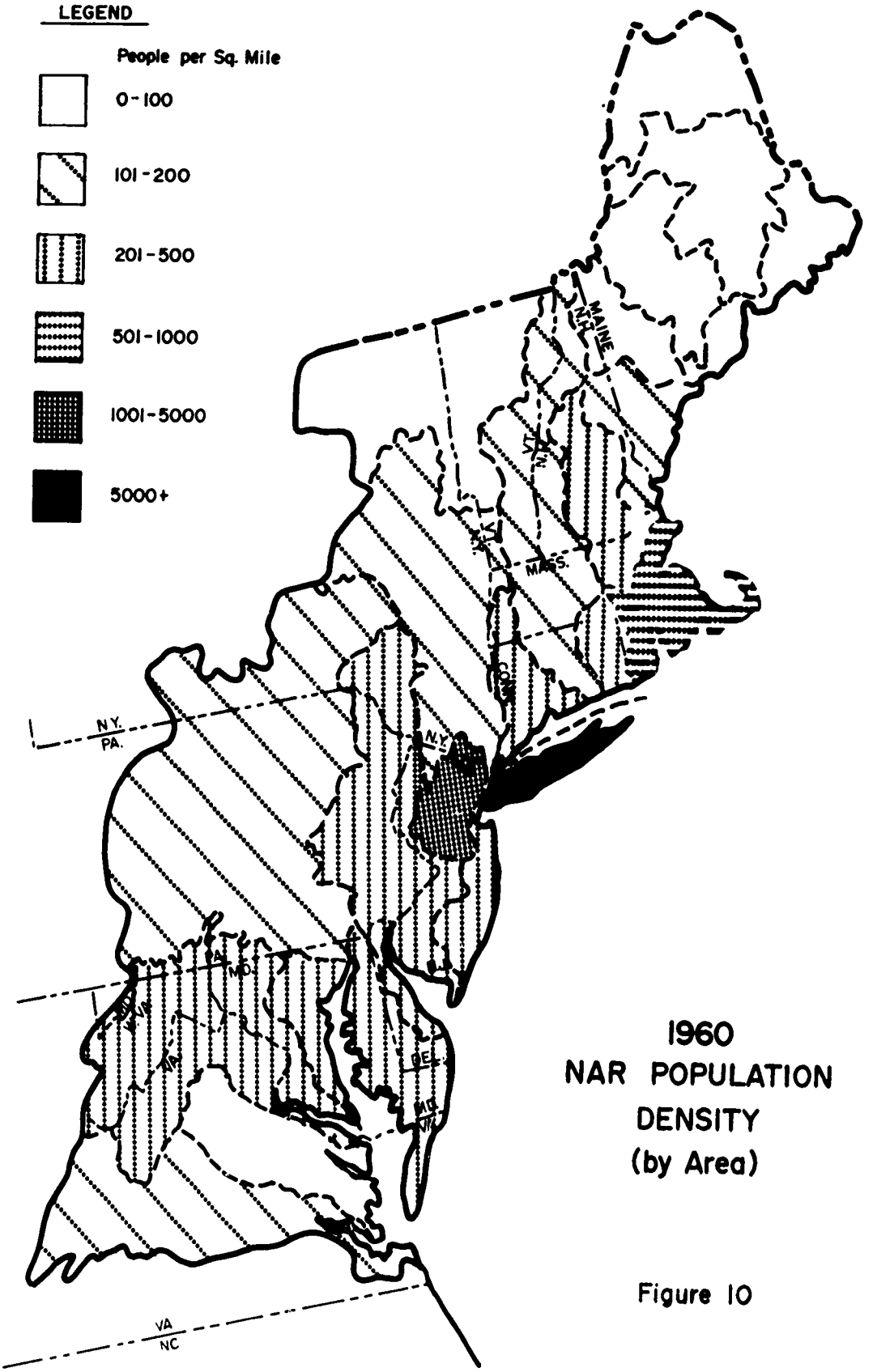
SOCIAL

Population

The North Atlantic Region, with only five percent of the Nation's area, but 26 percent of its 1960 population, is the most densely populated U. S. region of its size, and the most urbanized region in the United States. Most of the approximately 44.5 million people in the Region (1960) are tightly concentrated in an urban belt following the coast line from Boston to Washington, with an "island" of urbanization around Richmond, Virginia. This urban belt has less than 40 percent of the NAR's total area, but over 80 percent of its population. The five core cities of Washington, Baltimore, Philadelphia, New York City and Boston, excluding suburbs, contain almost three out of ten residents of the NAR. As indicated in Figures 10 and 11, the population density in these areas is very high, ranging up to 24,500 people per square mile in New York City.

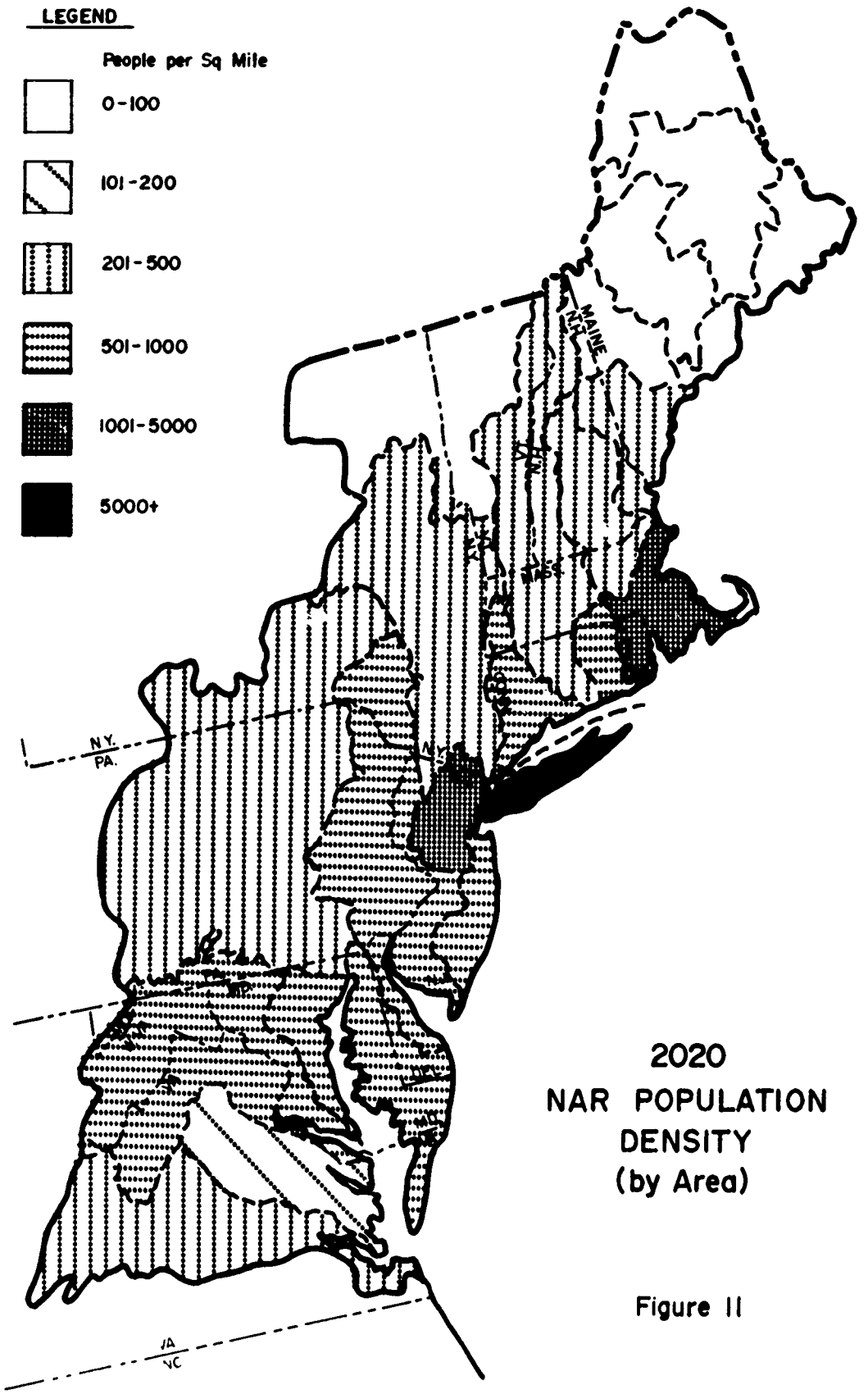
The cultures of the Region are extremely diverse, with a spectrum of local customs and traditions from Old South to Maine Downeaster, from Appalachian mountaineer to cosmopolitan Manhattanite. Ethnic, occupational, and social subcultural diversity is accompanied by an administrative patchwork of state, local and regional government.

Even with this enormous variety of life styles and outlooks that imply considerable conflicts, many attitudes are held in common by large numbers of people in the NAR. With the high degree of mobility that has been evidenced, from farms to cities and from cities to suburbs, increasingly fewer residents of the Region have purely rural backgrounds and outlooks.



1960
NAR POPULATION
DENSITY
(by Area)

Figure 10



2020
NAR POPULATION
DENSITY
(by Area)

Figure 11

The move to urban and suburban living stems not only from the NAR's original rural background and the valued concept of home ownership, but is also from the desire to live in high quality landscapes, awareness of the need to preserve available resources, and willingness to live in better planned communities which provide more services than rural areas and are, for some, an attractive alternative to city dwelling.

There is a growing consumer consciousness, concerning not only marketable material goods, but the environment and the quality of life as well, and a general interest in the alleviation of poverty and inequalities of opportunity. Successful water resources planning needs to reflect, to some degree, these intersecting (and occasionally conflicting) influences. With greater population densities, social problems are being increasingly brought to the foreground and made explicit in water resources planning studies such as the NAR Study, since the availability and quality of water has much to do with the quality of life. It is not only to the usual commercial, industrial and residential uses that water must be supplied in urban areas, but to other urban systems as well, such as those relating to recreation, open space, transportation and environmental health. All these systems should be taken into acccunt in planning for the development of water and related resources of the NAR.

The population of the NAR is expected nearly to double by the year 2020, to 86,1160,200 persons. Figure 12 shows the Regional growth and Table 4, the population by Areas for 1960, 1980, 2000 and 2020. The rate of growth is about four-fifths of that projected for the country as a whole, and as a result the NAR's share of the projected national population in 2020 will decline to about 22 percent. This total population will become even more predominately urban than at present, and urban areas will grow in physical size. However, it is not anticipated that central-city population densities will substantially increase, but rather that population growth within the urban belt will occur mostly in the suburbs, with some of these developing into new urban concentrations.

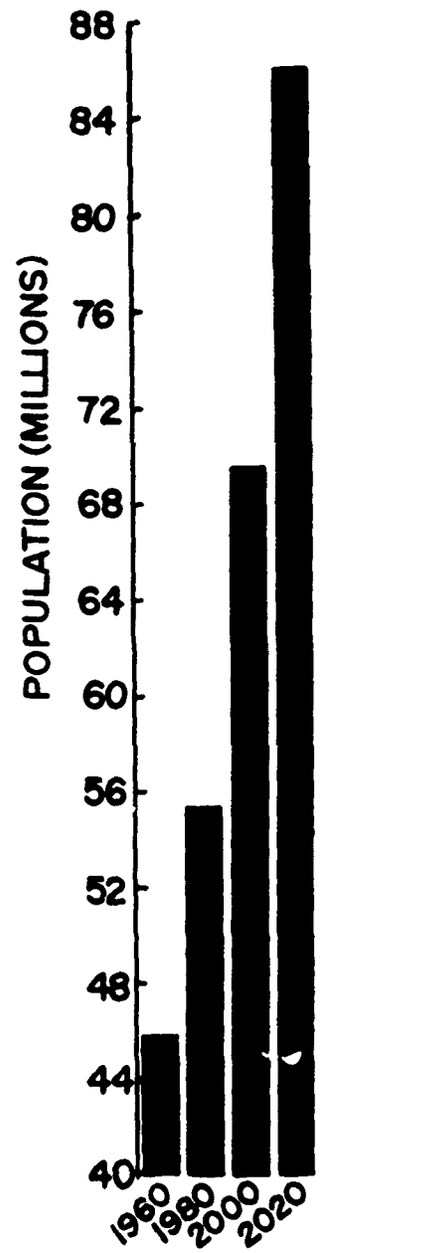


Figure 12

TABLE 4
POPULATION BY
NAR AREAS, 1960-2020

AREA	1960	1980	2000	2020
1	106,064	117,700	137,700	161,400
2	143,725	158,700	186,200	219,000
3	148,968	167,400	188,500	217,100
4	130,657	143,700	154,600	183,100
5	157,698	175,400	204,900	240,000
6	456,810	579,500	734,000	916,600
7	1,229,505	1,437,500	1,860,000	2,192,300
8	1,640,414	1,907,600	2,319,600	3,039,300
9	4,324,527	5,311,400	6,516,700	8,093,800
10	1,898,946	2,550,800	3,359,900	4,104,900
11	511,654	587,800	676,700	792,600
12	1,967,032	2,642,800	3,671,700	5,068,300
13	10,557,830	12,241,400	13,778,200	15,490,000
14	4,118,903	5,192,000	6,720,000	8,427,300
15	6,356,474	7,804,000	9,609,800	11,853,500
16	652,077	1,082,000	1,707,000	2,290,000
17	3,182,731	3,902,700	4,902,100	6,097,400
18	2,183,937	2,767,300	3,445,300	4,261,300
19	2,971,008	4,433,900	6,337,800	8,626,700
20	304,301	381,800	518,100	737,000
21	1,579,197	2,057,500	2,583,600	3,198,500
NAR	44,622,468	55,642,900	69,612,400	86,199,800

Economics

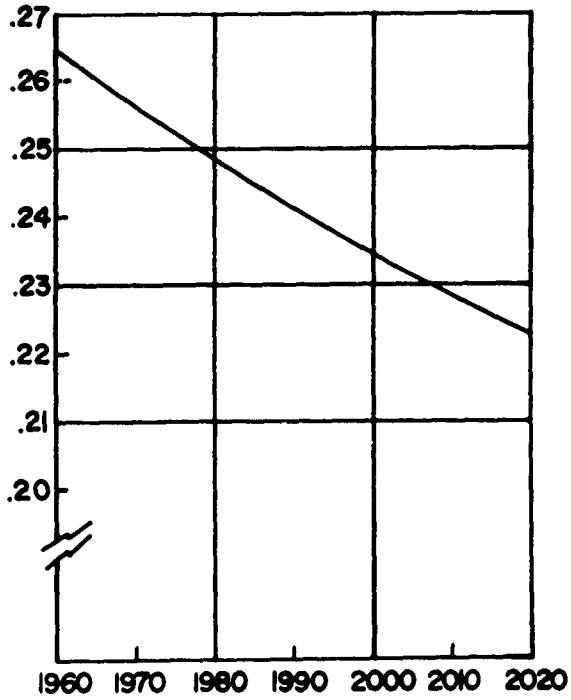
The NAR plays an important role in the nation's economy. The population of the Region in 1960 was 26 percent of the national total and received about 30 percent of the country's total personal income in that year. This resulted in per capita income 14 percent above the national average.

The important economic activities in the Region are manufacturing (including manufacturing in such water-using industries as textiles, chemicals and paper products), Federal government activities, and the finance and service industries. Extractive activities (mining, agriculture, forestry, and fisheries), play a relatively small role. The importance of population-related activities such as trade, transportation, and construction is, on a relative basis, about the same in the NAR as the Nation as a whole.

Since manufacturing, government, finance, and services are relatively labor-intensive, they tend to be localized in and around the densely populated urban belt of the Region. Examples include the New England textile industry, electronics in the Boston area, the finance, publishing, and garment industries in New York City, petrochemicals in northern New Jersey, and government in Washington, D. C.

Land and resource-intensive agriculture, fishing, forestry, and mining are important in the less populated exurban areas, where land is not at a premium, or where scarce resources are located. Examples include coal mining in the Susquehanna and Potomac River basins and commercial fin and shell fisheries in the Chesapeake Bay estuarine system.

The NAR is presently growing at a slower rate than the nation as a whole, as measured by population, employment, and income. As an older, more mature Region, its original leading position is being gradually eroded by younger regions entering periods of substantial growth. This general growth rate differential is projected to continue to 2020 and is shown for employment in Figure 13.



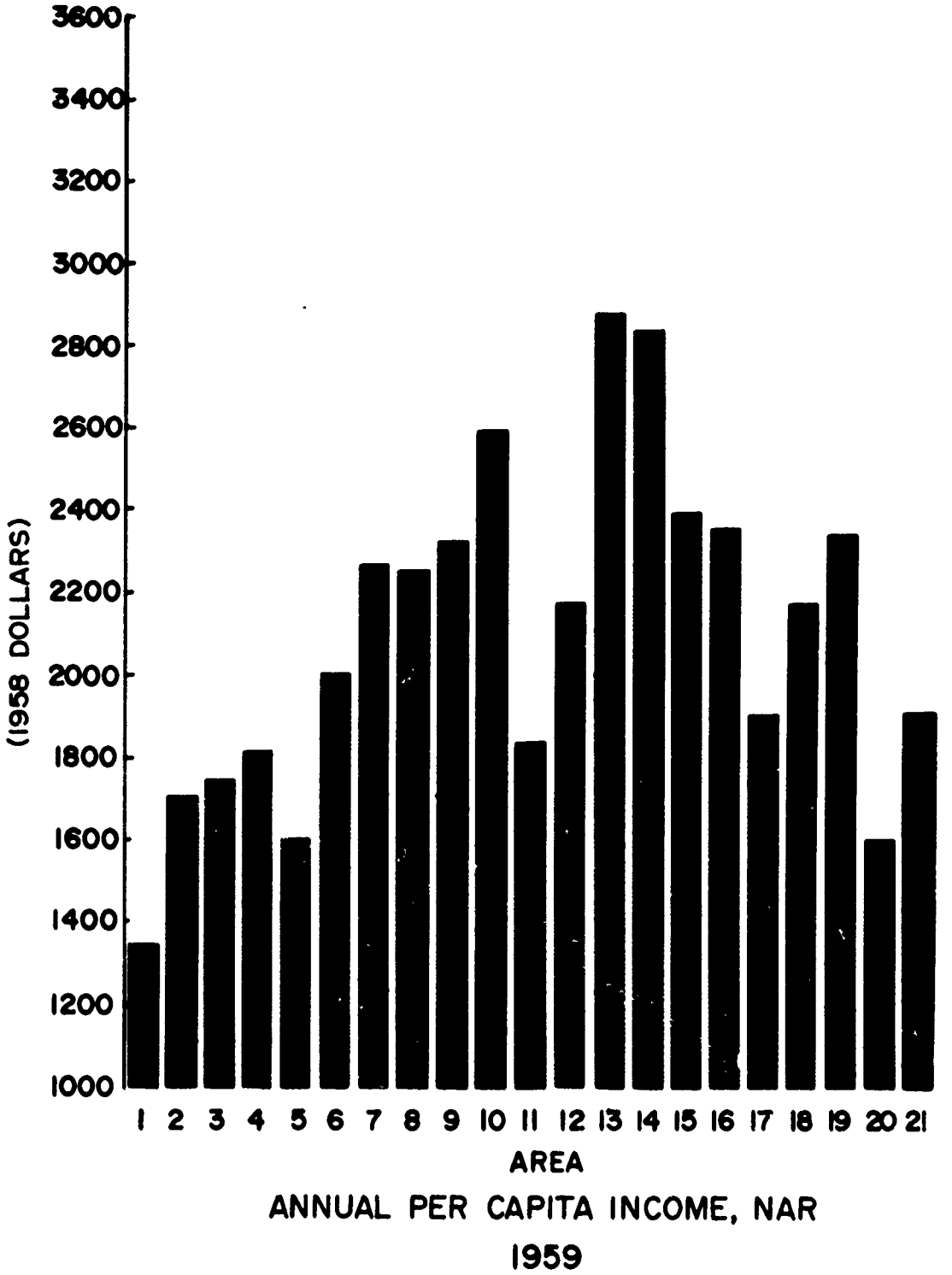
RATIO OF TOTAL EMPLOYMENT
NAR / U.S.

Figure 13

TABLE 5

EMPLOYMENT
IN MAJOR ECONOMIC CLASSES
BY NAR AREAS, 1960-2020

AREA	1960	1980	2000	2020
1	34,642	43,300	52,000	61,900
2	50,090	62,300	74,700	88,800
3	54,628	66,000	77,100	90,300
4	50,806	61,400	71,700	84,000
5	52,275	65,000	77,700	92,300
6	174,402	219,700	269,600	328,600
7	490,305	626,700	784,900	965,800
8	651,527	835,100	1,046,400	1,292,800
9	1,723,669	2,172,000	2,683,000	3,259,400
10	756,721	984,300	1,346,700	1,555,100
11	171,108	210,300	260,300	317,200
12	731,623	1,041,300	1,434,500	1,959,000
13	4,345,600	5,301,100	6,025,400	6,786,400
14	1,649,615	2,140,500	2,713,900	3,328,000
15	2,480,736	3,154,100	3,881,900	4,754,700
16	234,350	394,600	649,200	867,300
17	1,177,519	1,543,300	1,949,200	2,405,700
18	834,894	1,126,600	1,438,100	1,775,300
19	1,185,717	1,869,600	2,704,800	3,703,700
20	121,159	136,400	178,400	237,200
21	621,149	854,000	1,079,700	1,337,100
NAR	17,592,535	22,907,600	28,699,200	35,290,600



ANNUAL PER CAPITA INCOME, NAR

1959

Figure 14

The urban belt of the NAR is expected to grow both in area and in share of the Region's total population over the study period. This change is concurrent with migration within the urban belt from central cities to suburbs. A swiftly growing strain on land use management practices in the suburbs may be expected as a result of these population changes, along with increasing pressure on water supply facilities, sewage disposal and waste treatment plants and electric power generating capacity. All of these changes directly and indirectly affect major aspects of water and related land resources planning.

The total demand for water in manufacturing will increase although the relative importance of this in the NAR is expected to decline moderately. Manufacturing activity is likely to be shifted from central cities to suburbs, both to follow the labor force and to expand on the less expensive land. Agriculture, forestry, fishing, and mining are projected to decrease in relative (and, in some cases absolute) importance as land values are pushed upward by the spread of urbanization and industrialization. However, an element of uncertainty exists here: the crisis in power generation and the development of coal gasification techniques, for instance, could introduce new vigor into the coal extraction industry, or the advent of controlled thermonuclear fusion could render it obsolete. Then, too, there are the untapped mineral reserves of the continental shelf, such as the huge beds of oil and gas off Long Island, whose exploitation depends on the political resolution of opposing pressures of economics and environmental protection.

The economic base of the Region as a whole, and of the urban areas in particular, is expected to evolve in the direction of the "office" activities of government, finance, and services. As in the case of manufacturing, employment in these "office" occupations is projected to shift outward to the suburbs with the general population.

Employment in the Region is shown in Table 5 by major groupings and for heavy water using industries for the 1960 to 2020 planning period. The great variations in per capita income existing in the Region are presented in Figure 14.

Land and water characteristics of the Region have not served in general to limit economic development, and are not expected to do so in the future. The NAR as a whole is well endowed with water, and with certain exceptions, droughts have been comparatively mild and localized. The geographic distribution of water is uneven, however, posing an essentially Region wide problem of management and allocation. Although the NAR is the most urbanized region in the nation, its urban belt occupies less than 40 percent of its land area, and it is therefore evident that the future economy of the Region will be shaped more by the decisions of man than by the restrictions of nature on land and water supplies.

Land Use

Forest cover is by far the largest land use in the NAR with about 66 percent of the total acreage, followed by cropland with 15 percent urban, and "other" (roads and open tracts) land uses with 13 percent, and pastureland with 6 percent.

The Region is characterized by a widely divergent population density ranging from the lightly populated wildlands and wilderness areas of northern Maine to the heavily concentrated center-city and urban "megalopolis" stretching from Boston to Washington, D. C.

This "megalopolis" of urban and suburban development occupies between 30 and 40 percent of the Region's area and between 81 and 86 percent of its population, depending on "megalopolis" definition.

Institutional Arrangements

In part because the NAR has been well endowed with water, a comprehensive body of case law has not been generated to resolve water rights controversies. The common law rule, with its variety of interpretations, still stands: a riparian owner has the right to reasonable use of water which flows by his property.

More important for water management in the NAR is the volume of statutes governing water use and the number of agencies that administer this use under statutory guidelines. It is these statutes, the source of authority for the agencies with which the local planner deals, that have formed the basis for interagency and intergovernmental cooperation on the NAR Study. Institutional arrangements for planning the development of water and related resources in the NAR encompass each of the many levels of government, and each of the agencies which executes and administers the laws governing those resources. These levels include Federal, state, local, regional, river basin and interstate agencies.

There has been considerable reorganization on all levels of government in recent years in response to a new awareness of the importance of protecting and preserving our resources and the environment. Even greater reorganizations are being actively considered at all levels and changes can be expected to continue for some time.

Planning conducted by Federal agencies is carried out in close cooperation with appropriate regional, state and local planning, development and conservation agencies, to the end that National, regional, state and local objectives may consistently be accomplished to the greatest extent possible. Such cooperation and coordination between the thirteen NAR states and the District of Columbia is an integral part of the NAR Study. The states not only administer use, development and preservation of state resources, and coordinate local agency activities, but also participate in Federal projects and handle Federal grants. The states also participate in various interstate organizations dealing with resources development or control.

A relatively new development in water resources planning and management, and one of marked significance, has been the advent of cooperative interstate-Federal river basin commissions. These, which include the New England River Basins Commission, the Delaware River Basin Commission, the Susquehanna River Basin Commission, and the proposed Potomac River Basin Commission vary in their powers from merely providing coordination, planning and technical advice, to direct control, regulation and management of the water and related resources within their jurisdictions.

HISTORY OF WATER USE

Water resources were of primary importance in the early history of the North Atlantic Region. Early settlements in the 17th century developed around a few natural harbors from Virginia to Massachusetts. The only effective mode of transporting people and goods was by water along the coast and on the rivers. As the colonists extracted timber from the forests and cultivated the land, trade with Europe increased and the port cities grew.

Before long industries developed which were linked to the sea trade -- shipping, ship building, flourmilling, rum-making and food preservation. While the South flourished with agriculture the North concentrated on trade and industry.

By the time of the American Revolution, five cities in all of the colonies had populations of more than 10,000. Philadelphia (40,000), New York (25,000), Boston (16,000), Charleston (14,000) and Newport (11,000). In addition, eleven cities and townships had populations between 5,000 and 10,000 with all but one (Norfolk) north of Virginia. By this time, also, inland development in Massachusetts, Connecticut, Pennsylvania and Virginia had become disengaged from the sea coast. Immigrants sought richer agricultural lands and moved westward toward the Appalachians.

Agriculture and forest products have been major influences in the development of the NAR. In colonial days, land seemed to be an inexhaustible resource, and was exploited extravagantly. In the south, agricultural land was plentiful and tobacco farmers moved from exhausted fields to other productive land further inland.

Farmers in the middle colonies in later years adopted better agricultural practices and produced grain, potatoes and fruit as well as livestock. Colonial forests were harvested with abandon to supply lumber for a variety of purposes in the domestic and European market. The water resources of the Region were used to aid this harvesting through the transportation of log o the sawmills.

In the 19th and early 20th centuries, more scientific methods in both agriculture and forest management conserved the land and increased productivity. In recent years, demand for developable land to support increasing urbanization has taken many wetland and forest areas for these uses and, in other instances, has increased land values and taxation on agricultural uses near urbanized areas Thus, it has now become increasingly difficult for agriculture in the NAR to compete with agriculture areas not subject to such economic pressure.

Water as a source of power was developed initially in the colonies through the water wheel used primarily for milling. Early in the 19th Century, textile manufacturing was lured to the water power generated by fast streams in New Hampshire, Massachusetts, northern New Jersey and western Pennsylvania, and industrialization in the Region began to increase.

Before the advent of the railroad, transportation by natural waterways and inland canals promoted economic activity and growth by linking the coastal cities with inland centers. Early in the nineteenth century, canals such as the Erie opened up substantial areas of New York and Pennsylvania to settlement. However, once rail roads were constructed to serve the same areas, the small, early canals could not compete in time or cost, and gradually decreased in use.

As the 19th Century progressed, transportation facilities and commerce, industry and corresponding urban development became complementary to one another. As commerce and industry grew, more highways, railroads and large canals and port facilities were required; the improved transportation that resulted then attracted more commerce and industry. The cities, with their job opportunities attracted immigrants and the belt from Boston to Baltimore filled in to form a string of metropolitan areas.

With increasing industrialization came increased use of water for industry. With increasing population and income in metropolitan areas came greater use of water supplied by public and private sources and increased demand for water recreation. Both industry and the urban population returned used water to the streams with little or no effort expended to remove pollutants. In the last century, this practice created few problems, but the increased industrial and population densities of recent decades have brought about concentrations of pollution that no longer can be ignored.

CHAPTER 3

RESOURCE UTILIZATION AND MANAGEMENT; PRESENT AND FUTURE

A survey is given in this Chapter of the present use of water and water related resources in the NAR. This information is needed to understand the present role each resource plays in the Region's economic and cultural activities. Resource categories used for this survey are similar to those used for the classification of the Study needs.

MINING

Total mineral production in the NAR in 1964 was valued at $1.17 billion, about 7 percent of the United States total. The Region produced nearly 19 percent of the value of those nonmetallic minerals produced Nationally. The rate of growth for the mineral industry as a whole is expected to be less than that for the United States, with actual projections being linked closely to industrial productivity and population projections. In 1970, the value of mineral production in the NAR was $1.3 billion, 4 percent of the U. S. total of $29.8 billion. Increases can be expected if presently known mineral resources are developed and new deposits are found. NAR and U. S. mineral production in 1964 is compared in Table 6. The principal minerals mined in the Region, in descending order of value, are stone, cement, sand and gravel, coal, iron ore, and zinc. The NAR yielded the total U. S. production of anthracite coal and emery and more than half of the total value of U. S. production of aplite, asbestos, cobalt, garnet, greensand marl, kyanite, manganiferous residuum, titanium concentrates, and wollastonite.

Coal and natural gas production in 1964 made up nearly 25 percent of the mineral value in the NAR, while crushed stone accounted for 21 percent, cement 20 percent, and sand and gravel 12 percent. Total metallic mineral production accounted for only 10 percent of the NAR mineral value.

Emery is mined only near Peekskill, New York (Area 12), and is used primarily as a non-skid element in pavements and stairways. High grade emery for use in metal abrasive paper and in machinery is imported.

Anthracite coal is mined in the United States only in the Delaware and Susquehanna River Basins (Areas 15 and 17). In the last ten years the average annual production has dropped 6.4 percent. Deep mining has declined owing to high extraction costs, while strip mining and production from culm banks have increased.

Large deposits of anthracite coal are still available, but many mines have been abandoned as demand has declined since World War I. Many of these abandoned mines are now filled with acid-, iron-, and manganese-bearing water. Draining these mines would be costly and would add to already serious acid mine water pollution problems. The high recovery costs will continue to drive production down, but it is expected to level off at three million tons annually within the next 30 years.

Bituminous coal production is important in the NAR and in 1964 nearly equaled anthracite production in value ($ 138 vs. $149 million). Bituminous coal is found in an area along the NAR's western border in counties in West Virginia, Maryland and Pennsylvania. There are several small deposits in eastern Virginia, but none have been in production for many years. Seams in the Susquehanna River Basin (Area 17) yield 92 percent of the Region's production. Future production will be affected by pollution control legislation influencing recovery operations and use of the product. The percentage of the energy market held by coal may decrease but it is probable that the quantity of bituminous coal production may increase.

Other mineral commodities of substantial value (over $50 million production) in the NAR are:

TABLE 6

MINERAL PRODUCTION IN THE NORTH ATLANTIC REGION AND IN THE UNITED STATES, 1964*

		North Atlantic Region		United States		NAR Percent of the United States	
		Quantity	Value	Quantity	Value	Quantity	Value
		(thousands)	(thousands)	(thousands)	(thousands)		
Cement:							
Portland	376-pound barrels	70,956	$214,415	366,304	$1,168,987	19.4	18.3
Masonry	280-pound barrels	5,308	14,043	22,397	63,305	23.7	22.2
Clays	short tons	6,212	16,795	52,853	192,539	11.8	8.7
Coal:							
Anthracite	do	17,184	148,648	17,184	148,648	100.0	100.0
Bituminous	do	31,073	137,744	486,998	2,165,582	6.4	6.4
Copper	do	4	2,356	1,247	812,901	0.3	0.3
Emery	do	9	172	9	172	100.0	100.0
Feldspar	long tons	96	847	587	5,389	16.3	15.7
Gem Stones		NA	97	NA	1,474	-----	6.5
Iron Ore (usable)	long tons, gross weight	4,941	71,060	84,300	802,331	5.9	8.9
Lead (recoverable content of ores, etc.)	short tons	1	192	286	74,936	0.3	0.3
Lime	do	3,024	38,552	16,089	223,167	18.8	17.3
Natural Gas	million cubic feet	14	3,792	15,547	2,387,689	0.1	0.2
Peat	short tons	88	991	640	6,198	13.8	16.0
Salt	do	4,654	28,833	31,623	200,706	14.7	14.4
Sand and gravel:							
Commercial	do	105,595	134,269	621,392	700,051	17.0	19.2
Government-and-contractor	do	25,126	9,646	247,387	194,041	10.2	5.0
Stone:							
Crushed	do	142,940	243,724	722,724	1,037,365	19.8	23.5
Dimension	do	734	37,343	2,545	96,970	28.8	38.5
Talc	do	415	2,469	890	6,218	46.6	39.7
Zinc (recoverable content of ores, etc.)	do	124	33,805	575	156,308	21.6	21.6
Value of items that cannot be disclosed**		XX	26,815	XX	301,180	XX	8.9
Grand Total		XX	$1,166,608	XX	$10,746,157	XX	10.9

NA Not available. XX Not applicable.

* Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

** These items include aplite, asbestos, cement (natural), cobalt, abrasive garnet, gold, greensand marl, kyanite, magnesium compounds, manganiferous residuum, mica, potassium salts, pyrites, silver, titanium concentrates, tripoli, and wollastonite.

1. Crushed stone – this has the highest total value of mineral production in the NAR; output in 1964 totaled 143 million tons valued at $242 million. Crushed stone is produced throughout the NAR. The greatest production is in Pennsylvania, 32 percent of the NAR output in 1964 followed by New York and Virginia.

2. Portland cement – in 1964, shipments in the NAR totaled over $214 million. Production was centered principally in Northampton and Lehigh Counties, Pennsylvania, and in the Hudson River Valley of New York. Other plants are located in Maine, Maryland and Virginia. It is expected that production will keep pace with over-all construction projections.

3. Iron ore – in 1970, was mined in the Region only in New York and Pennsylvania, though there are many deposits throughout the Region. Production of this low grade or limited sized ore is not expected to increase significantly. The only significant ore production increases are expected for zinc, copper and titanium.

4. Commercial sand and gravel – also found throughout the NAR. The largest producers are located near the large population centers.

More than half of the mineral industry employment in the Region is concentrated in the Delaware and Susquehanna River basins (Areas 15 and 17), chiefly in the coal industry. The remaining mining employees are distributed throughout the NAR and are engaged mainly in stone quarrying and sand and gravel production.

Minerals require varying quantities of water for their production. Based on total amounts of water used, the most important mineral products of the Region are sand and gravel, coal, stone, iron ore, and titanium.

The Atlantic Continental Shelf is an untapped source of minerals of potentially great importance, particularly sand and gravel, especially by 2020. By this time, land sources for sand and gravel in areas of "megalopolis" could be seriously depleted. Aggregate production is expected to more than double by 2020 due to continuing highway and building construction. The Shelf is also a potential source of petroleum and/or natural gas production.

AGRICULTURE

Increased consumption of food and fiber has been caused by a higher population and by increased personal income. At the same time, there has been a decrease in the acreage devoted to nearly all of the principal crops grown in the NAR. There has not been a corresponding decrease in production over-all, although some individual crops have declined. Yield increases primarily due to technological improvements and retirement of marginal land have tended to compensate for declines in acreage. In few cases, if any, has total production increased as much as demand. Thus, it is apparent that the farmers of the NAR supply only a portion of the Regional agricultural product requirements.

Most areas in the Region show a similar pattern of decline in the acreage devoted to agriculture. No major shifts in production areas were apparent during the 10-year period from 1954 to 1964. Total cropland acreage is expected to continue to decline. Based upon present trends, the percentage of cropland to the total NAR area will decrease from the 1963 level of 15.2 percent to 6.0 percent in 2020 (Table 7).

TABLE 7
PERCENT OF NAR LAND IN CROP PRODUCTION BY AREAS, 1963-2020

AREA	1963	1980	2000	2020
1	5.2	4.3	2.9	1.8
2	3.9	1.3	0.6	0.3
3	8.0	2.7	1.5	0.8
4.	6.2	3.0	1.7	1.0
5	6.2	2.3	1.6	0.9
6	6.9	3.4	1.6	0.7
7	5.5	2.0	1.2	0.5
8	8.6	4.3	2.3	1.2
9	5.5	3.5	1.9	1.0
10	8.4	4.8	2.3	1.1
11	17.1	11.8	8.3	5.9
12	15.6	11.8	8.1	5.6
13	6.0	1.5	-	-
14	15.6	7.5	3.5	1.6
15	22.7	17.0	11.6	7.9
16	15.1	7.0	6.0	5.0
17	23.1	19.0	14.8	11.6
18	37.8	27.7	21.5	16.8
19	19.7	18.1	14.1	11.1
20	15.6	12.7	9.4	6.9
21	9.6	8.9	6.3	4.5
NAR	15.2	11.4	8.2	6.0

Feed grain - corn, sorghum, oats, and barley - acreage harvested in the Region has declined nearly a third from 3,397,700 acres in 1954 to 2,293,200 in 1964. None of the Areas experienced an acreage increase over this period. More than 55 percent of the Region's feed grain production has grown in the Susquehanna and Chesapeake Bay Areas in 1964. Considerable quantities of feed grain are also produced in the Delaware and Potomac River Basins (Areas 15 and 19).

Food grains - wheat, rye and soybeans - are concentrated largely in the south. Nearly 99 percent of the Region's 1,238,300 1964 production acreage was in the Areas 14 to 21. There has been a gradual decline in both production and acreage due to the competition of efficient mid-western producers. The decline in wheat acreage was similar to that in feed grains. Grains will continue to be an important eastern crop because of their value as a nurse crop, as a vital element in crop rotations and as a means of satisfying the dairy farmers' demand for bedding straw.

Roughage production emphasis is shifting from hay to silage. Production of silage in the northern Areas is more significant than it is for feed grains. However, silage production still predominates in the southern Areas, and more than 50 percent of the Region's 1,205,000 acres is grown in Areas 17 through 21.

Hay acreage declined approximately 13 percent -- 6,482,300 to 5,590,200 -- throughout the Region from 1954 to 1964. Production declined by 1.6 million tons or 16 percent during the same period. Areas 11, 12, and 17 are the largest producers of hay with 54 percent of the Region's hay production.

Vegetable production is an industry with a yearly output of more than $100 million in the NAR. The concentration of this industry in particular Areas is important to local economies. Over 50 percent of the vegetable acreage is situated in the Delaware and Chesapeake Bay Areas. Among the other 19 Areas the acreage is about equally distributed.

Potatoes, like all the crops listed thus far, except wheat, are grown to some extent in all Areas although almost 50 percent of the acreage is located in the St. John River Basin. The Long Island Area is also an important potato producing area. Significant quantities are produced in the Delaware, Susquehanna and Chesapeake Bay Areas. Potato acreage has declined in most areas except in the St. John River Basin (Area 1).

In planning the use of land and water resources the amount of income that can be generated from alternative uses is an important factor. Most of the coastal plain area is in direct competition with non-agricultural uses. An examination of farm income and the sources from which it is derived is useful in determining how the agricultural economy will be affected by land and water planning.

In 1964 gross farm income from farming was slightly greater than 2.8 billion dollars in the NAR. This figure is projected to increase by 8 percent to just over 3.0 billion dollars in 2020. Sub-Region A is projected to have the highest increase of 55 percent with Sub-Region E next with 24 percent. Sub-Regions C, E and F will also experience increases, but Sub-Regions B and D will decline 25 percent and 24 percent, respectively (Table 8).

TABLE 8

GROSS FARM INCOME BY NAR SUBREGIONS, 1964-2020

Sub-Regions	Income 1964	Estimated Income 1980	2000	2020	Estimated Change 1980	2000	2020
		(Millions of Dollars)			(Percent)		
A(Areas 1-5)	203	240	300	315	+13	+42	+55
B(Areas 6-10)	415	340	325	310	-18	-22	-25
C(Areas 11-13)	485	499	530	600	+ 3	+ 9	+12
D(Areas 14-16)	478	430	380	365	-10	-21	-24
E(Areas 17-18)	835	910	955	1000	+ 9	+14	+20
F(Areas 19-21)	393	440	450	455	+12	+14	+16
NAR	2810	2830	2940	3045	+ 1	+ 5	+ 8

Source: Farm income from the "Farm Income Situation" was pro-rated among Areas according to county agricultural sales from the "Agricultural Census".

TABLE 9
CROP DISTRIBUTION
FOR IRRIGATED FARMLANDS
BY NAR AREAS, 1964

Area	Total farmland that is irrigated (acres)	potatoes	sweet corn	other vegetables and corn for grain	tobacco	berries	land in orchard	total nursery	all other crops
		(percent)							
1	300	90.0	-	-	-	-	-	-	10.0
2	700	88.6	2.5	-	-	-	-	-	8.6
3	100	10.0	20.0	50.0	-	-	-	-	20.0
4	700	42.9	5.7	25.7	-	-	-	12.9	12.8
5	600	20.0	8.3	16.6	-	51.8	-	-	3.3
6	2,400	25.0	12.9	35.0	-	-	-	1.7	25.4
7	5,700	3.2	23.5	37.7	-	.9	-	4.9	29.8
8	14,200	13.3	7.0	13.6	48.0	.3	-	7.5	10.3
9	17,600	3.3	6.0	15.4	-	63.3	-	3.7	8.3
10	5,100	39.8	6.5	20.2	3.3	-	-	3.9	24.5
11	1,000	10.0	2.0	6.0	-	-	-	6.0	76.0
12	17,300	6.0	15.7	32.2	-	.3	-	1.8	44.0
13	37,900	75.6	2.2	15.6	-	1.0	-	5.6	-
14	8,800	40.2	12.6	42.2	-	.7	1.1	3.2	-
15	83,800	16.9	7.2	55.0	-	5.6	10.8	3.9	.6
16	22,800	17.0	5.7	35.5	-	19.5	9.0	6.6	6.7
17	13,700	17.5	6.6	27.9	-	1.4	7.7	3.5	35.4
18	29,900	18.2	7.1	66.0	.9	1.4	.3	3.5	2.6
19	13,500	.7	1.2	5.5	8.8	.3	25.4	11.7	46.4
20	1,900	-	1.6	11.0	-	-	7.4	2.6	77.4
21	4,300	.9	3.7	22.6	23.3	1.4	6.5	2.1	39.5
NAR	282,300	23.4	6.9	36.8	3.3	7.8	5.7	4.7	11.4

The projected increases in agricultural income are due to improved technology (including management practices) in agriculture and improvements in yield per acre; production of animals due to better management; feeding efficiency; fertilizers; control of agricultural pests; and soil and water conservation practices.

Slightly over two-thirds of the NAR agricultural income is derived from livestock or livestock product sales. The development of the livestock economy hinges upon favorable topography, abundance of rainfall, and grass. Much feed, however, must be imported from other U. S. areas to support the industry.

Irrigation has been practiced in the NAR for as long as crops have been cultivated. As early as 1796 water was conducted through ditches and wooden pipes and applied to fields by furrows. Before World War II, however, irrigation in the NAR was not very important. The Region is normally blessed with a relative abundance of evenly distributed rainfall. Crop failures have been rare but reduced yields have not been uncommon. Hence, irrigation in the NAR is used as a supplement to natural moisture rather than as the only source of moisture for a crop. Following World War II, with the advent of light weight aluminum pipe and more efficient pumping systems, irrigation costs were lowered significantly, especially costs of maintenance and labor. Other technological improvements including "quick coupling" devices, and improved motors and fuels increased the efficiency of irrigation systems.

Improved equipment along with high product prices in the postwar years resulted in more favorable returns attributed to irrigation. During dry growing seasons the net returns to irrigation have been reported to be quite high. Returns to irrigation are not as dramatic in many growing seasons due to the relatively high seasonal rainfall. In 1964, vegetables, potatoes, and fruits made up a very large portion of the total irrigated acreage shown in Table 9. These crops will be totally irrigated by 2020, as will tobacco and cranberries.

Insurance against reduced yields due to drought condition is not the only consideration for using irrigation on many of the high value crops grown in the Region. Irrigation significantly increases the quality of tree fruits and vegetable crops. The use of irrigation systems for frost protection is becoming important to tree fruit, berry and vegetable production. Irrigation has also enabled the farmer to obtain a greater response from fertilizer through heavier applications and more efficient plant use. The sprinkler system has also provided the farmer with an efficient method of applying liquid fertilizer.

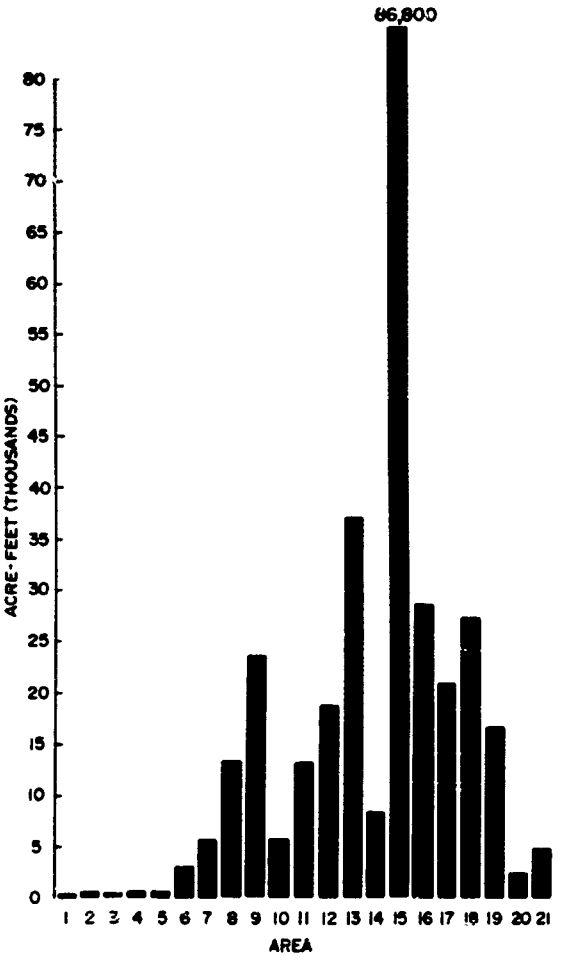
In the 1964 Agricultural Census there were 282,300 acres of irrigated land in farms in the NAR. This acreage represents less than two percent of the Region's Cropland and less than one percent of the total irrigable soil. It is evident that only a small portion of the cropland in farms is irrigated. However, since irrigation is practiced primarily on high value crops, the irrigated acres become more significant when considering total farm production. Irrigation of field and forage crops has been and will probably continue to be a marginal operation, and rarely undertaken even in combination with irrigation of other crops. Table 10 presents the present and projected, irrigated acreage by Areas. The amount of water used for agricultural irrigation today is presented on Figure 15.

Non-Agricultural Irrigation

Irrigation of golf courses and industrial and institutional lawns in the NAR requires two-thirds as much water as all agricultural applications, with nearly 90 percent of this accounted for by golf courses. This use of water, actually in the nature of a visual amenity, has enjoyed a strong growth.

TABLE 10
IRRIGATED FARMLAND
BY NAR AREAS, 1964-2020

Area	1964	1980	2000	2020
		(Acres)		
1	300	20,500	43,200	77,000
2	700	700	1,400	3,900
3	100	300	1,000	2,700
4	700	1,600	2,500	3,200
5	600	800	1,900	2,500
6	2,400	2,900	3,000	3,000
7	5,700	5,300	4,100	1,800
8	14,200	24,800	14,400	8,400
9	17,600	22,900	15,800	15,800
10	5,100	7,700	3,900	2,000
11	1,000	1,500	2,000	2,000
12	17,300	25,300	31,100	31,100
13	37,900	15,000	-	-
14	8,800	10,000	6,000	2,700
15	83,800	117,000	137,800	104,000
16	22,800	35,900	35,900	35,900
17	13,700	29,300	36,900	45,000
18	29,900	58,700	89,800	89,800
19	13,500	32,800	46,700	41,100
20	1,900	2,200	2,200	2,200
21	4,300	5,900	6,300	6,000
NAR	282,300	421,100	485,900	480,100



GROSS SEASONAL AGRICULTURAL IRRIGATION REQUIREMENT, NAR, FOR 1964

Figure 15

Areas 13 and 15 rank highest and Area 1 is lowest in non-agricultural irrigation which reflects their relative populations, income levels, and degree of urbanization (Table11). Over-all the Region's non-agricultural irrigation is expected to increase 27 percent by 2020.

TABLE 11
NONAGRICULTURAL IRRIGATION
BY NAR AREAS, 1967

AREA	GOLF COURSES	INDUST-RIAL	INSTITU-TIONAL	TOTAL
		(1000 acre feet)		
1	.4	1/	1/	.4
2	.5	1/	.1	.6
3	.7	1/	.1	.8
4	1.0	1/	.1	1.1
5	1.1	.1	.2	1.4
6	3.1	.2	.3	3.6
7	8.4	.5	.6	9.5
8	10.4	.3	.9	11.6
9	16.6	.4	.9	17.9
10	10.9	.5	1.0	12.4
11	4.4	.1	.3	4.8
12	12.5	.3	.6	13.4
13	17.9	.1	.2	18.2
14	11.2	.2	.4	11.8
15	26.5	1.1	4.6	32.2
16	3.8	.2	.9	4.9
17	14.9	.8	1.4	17.1
18	7.1	.5	1.5	9.1
19	13.2	.7	1.5	15.4
20	1.2	.2	.5	1.9
21	6.2	.4	1.1	7.7
NAR	172.0	6.6	17.2	195.8

1/ Less than 50 acre-feet

FORESTRY

Forested areas are the largest single land use in the NAR, encompassing about 66 percent of the land area. Forests are also the largest land use in each of the hydrologic Areas, except in Area 13 where urban land is 45 percent of the total, and in Area 18 where cropland occupies the largest portion of land area.

Commercial acreage makes up 62 percent of the land area in the NAR and is expected to remain at or near that level throughout the Study period. Only one tenth of forest acreage is maintained in public ownership with the remainder being privately owned either by farm and miscellaneous enterprises, or by the forest industry. Area 17 has by far the largest commercial acreage while Areas 13, 14 and 16 have the least. Table 12 shows present and projected acreage of commercial forest by Areas.

The commercial resources are made up of pulpwood, which is used in the pulp, paper and allied industries, and sawlogs, veneer logs and miscellaneous timber products, used in the lumber and wood products industries. The principal trees in use are pines, spruce, hemlock and various hardwoods. The hardwoods make up 64 percent of the growing stock inventory and predominate in the south while softwoods are more frequent in the northern reaches of the NAR.

Pulpwood and lumber and wood products each make up 43 percent of the total Regional growing stock cut, with the remaining 14 percent composed of fuel wood and miscellaneous timber products (1962). Pulpwood production is expected to almost triple by 2020, while the production of lumber and wood products will increase 74 percent.

TABLE 12
COMMERCIAL FOREST
LAND BY NAR AREAS
1962-2020

Area	1962	1980	2000	2020
	(thousand acres)			
1	4,021	4,075	4,121	4,170
2	4,166	4,303	4,303	4,162
3	3,593	3,522	3,526	3,401
4	1,422	1,310	1,392	1,392
5	3,189	3,348	3,348	3,159
6	1,964	2,071	2,021	1,922
7	2,252	2,323	2,323	2,030
8	5,699	5,780	5,780	5,405
9	1,470	1,550	1,429	1,066
10	2,053	2,104	2,101	1,953
11	4,058	4,683	4,832	4,527
12	4,617	5,311	5,792	5,301
13	409	419	292	229
14	527	456	385	246
15	4,316	4,238	3,800	3,353
16	645	696	659	595
17	9,161	9,814	10,634	10,651
18	1,424	2,384	2,144	1,904
19	5,327	5,442	5,614	5,120
20	2,134	2,123	2,292	2,292
21	4,891	4,616	4,960	4,833
NAR	67,338	70,567	71,748	67,761

Employment in both pulpwood and lumber and wood products production is expected to decrease throughout the planning period although pulpwood employment will not decrease until after 1980 because of the industry's expansion. Advances in technology and productivity will be the main factors of decreasing employment, but the employment distribution will also be affected by the fact that many semi-finished products will be shipped out of the Areas of origin for further conversions. One area where employment is projected to increase, however, is in the protection and management of forests for the production of timber and related products. Employment for this purpose will more than double through 2020 as resource production demands increase and public concern grows for natural resource protection and management.

Forest lands contribute significantly to the maintenance of land and water quality through erosion control, as a wildlife habitat, and for general recreation and esthetic purposes.

The forested sections of the NAR comprise the largest portion of catchment area for precipitation and serve as a storage reservoir and filtering agent between the primary source of supply and storage areas downstream. They lessen the quantity and velocity of water moving over the land surface, and absorb quantities which percolate into groundwater storage for aquifer recharge. These forested sections have in some cases been overcut by exploiting industries or have been ravaged by fire which increases runoff damage in the form of erosion and pollution. Reforestation can be used to retard runoff, to check erosion, and to control pollution sources in waters to be used by downstream municipalities.

The forest also supplies the largest single class of wildlife habitat, providing food and shelter for forest game and non-game animals and smaller animals and water fowl. These forest animals have an economic and social impact on the NAR through consumptive uses such as hunting and non-consumptive uses: wildlife photography, bird watching, hiking and nature walks. The forest's retarding effect on erosion and sedimentation also supply quality water for fresh water fisheries.

The forest environment provides the major base for future development of Federal, state and private recreation facilities in the NAR where the demand for forest-related outdoor recreation has been substantial. The private sector, which has the most enterprises providing the largest number of sites, offers great potential in providing campground opportunities to the public. The recreation area in private ownership, though not as extensive as Federal or state holdings, is highly developed. Forests are also an integral part of the visual and cultural environment of the NAR, forming the basic unit to which other types of landscapes are added.

FISHING, HUNTING AND NATURE STUDY

The ability of the Region's fish and wildlife resources to meet hunting and fishing needs has been decreased by the lack of public access, destruction and alteration of wildlife habitat, and a general decrease in the resource base accompanied by increasing demand.

Wildlife for hunting purposes is divided into four main categories: big game, small game, migratory game and fur animals. The types of fishing in the NAR include freshwater fish, anadromous fish and saltwater sport and commercial fish.

In the big game category deer is the most sought-after animal in the NAR. Black bear is a much desired trophy animal. Over half the bear kills in 1965 were in Maine with 1,500 kills, while only 400 were killed south of New York State. The other big game animal is moose, found only in Maine and New Hampshire. Moose cannot presently be legally hunted, but are a valuable esthetic attraction. The habitat for big game is projected to remain fairly constant through 2020 (Table 13).

Farm game that are hunted include pheasant, quail and rabbits. Most hunting for farm game occurs in Areas 15 and 17, with lesser amounts to the north and almost none to the south. Wild turkey, which was partially restored in various parts of the Region, is hunted to a limited extent. The capability of these small game resources will be significantly reduced, as also shown in Table 13; but by 2020, capabilities can be increased if maximum species yield programs are implemented.

TABLE 13
WILDLIFE HABITAT
FOR NAR, 1965-2020

	1965	1980	2000	2020
	(square miles)			
Big Game	97.7	101.3	103.0	98.4
Small Game				
Forest	103.7	106.4	107.8	103.7
Farm	57.0	47.4	36.9	30.3
	(acres)			
Waterfowl	4101	3669	3308	3005

Migratory game includes water fowl, dove and woodcock. The Atlantic Flyway, one of four migratory routes through the United States, supplies many species of waterfowl attractive to hunters: Canada goose, brant, black duck, redhead, scaup, canvasback, teal, woodduck and mallard. Projected waterfowl capabilities will also decrease through 2020, shown in Table 13, but can also be augmented through management programs.

The demand for pelts from fur animals varies widely according to fashion trends and, thus, kills for various species are erratic. Commercial breeding farms also provide large amounts of some species.

Of the different types of fishery resources, freshwater fish have very little commercial value in the Region, being primarily used for recreational purposes, but the salt water and anadromous species appeal to both sport fishery and commercial interests.

The present and future capability of various fish habitats to sustain sport fishing in the NAR is shown in Table 14, along with the present demand. Freshwater fishing in warm water lakes of the Region experiences twice as much participation as that in cold water streams or lakes, and over three times as much as warm water streams. The catches, which are rarely large enough to be anything more

TABLE 14
REGIONAL SPORT FISHERY DEMAND, 1965
AND ESTIMATED CAPABILITY, 1965-2020

	Demand	Capability			
Fish Habitat Class	1965	1965	1980	2000	2020
	(thousands of man-days)				
Fresh water					
Streams					
Coldwater	11,077	10,734	11,072	11,506	11,857
Warmwater	7,921	5,954	6,237	6,603	6,897
Lakes					
Coldwater	11,344	11,344	12,578	14,797	15,387
Warmwater	26,399	23,182	24,915	27,018	28,659
Total Fresh-water	56,741	51,214	54,802	59,924	62,800
Anadromous	2,120	1,483	1,592	1,683	1,773
Saltwater	36,567	36,567	37,315	38,206	39,097
Total Sport-fishing	95,428	89,264	93,709	99,813	103,670

than recreational or sport fishing, include small mouth and large mouth bass, northern pike, catfish and various types of small pan fish. Fishing in cold waters includes various types of trout, and landlocked salmon and smelt, all of which are attractive to anglers. Seasonal stocking programs are necessary to permit resources to stay abreast of the demand for trout fishing throughout the NAR.

Anadromous species are much more popular than the smaller fresh water fish. There is presently a great deal of demand for anadromous fish, such as the American shad, striped bass and the Atlantic salmon, in the Region's few remaining freshwater streams that remain unhindered by dams, or which have not been rendered unsuitable by pollution or over-fishing. There is also a great deal of latent demand for anadromous fishing in areas where these fish have disappeared. The supplies of anadromous fish do not meet either the demand of sport or commercial fishermen in the Region. Alleviation of pollution, incorporation of fish passage facilities, removal of obsolete dams, fish stocking and increased fisherman access are but a few of the many programs that need accelerating.

Estuarine dependent fisheries -- shellfish, seaworms, edible finfish and industrial fish -- are under great pressure from pollutants carried to the estuaries by the rivers, or dumped there purposely or by accident. Low flows also allow the oyster drill and predaceous starfish to intrude with the more saline water into the tidal marshes and mud flats.

These estuarine dependent resources of the Region could annually supply 800 million pounds of seaworms, shell fish and edible and industrial fish for the commercial fisheries industry of the NAR as shown for these categories in Table 15. These species depend for food on the plankton generated in the estuarine areas which, as they become polluted, produce less of this food.

The developable capability of salt water sport fishing is very large in the Region as it includes all of the Region's anadromous species, smelt, which are important also as a commercial fish in coastal waters, and the several varieties of fin fish that breed off the coast of the NAR and in its estuaries. Salt water sport fishing produces more fishing satisfaction than an equivalent amount of fresh water fishing and more public access is needed for saltwater fishing in the form of piers, ocean frontage for surf casting and boat-launching facilities.

TABLE 15
POTENTIAL SUPPLY OF COMMERCIALLY HARVESTED ESTUARINE DEPENDENT SPECIES, NAR

Commercial Species	Supply 1/
	(100,000 Pounds)
Edible Finfish	169.2
Industrial Finfish	482.2
Shellfish	147.0
Seaworms	2.4
Total	800.8

1/ Supply is a measure of the sustained yield (harvest) that estuarine resources could support under present environmental conditions.

Nature study is probably the most extensively pursued yet least understood outdoor recreation activity in the NAR. The types of people participating in nature study range from rugged outdoor types who observe wildlife for long periods in the most remote wilderness areas to groups of the elderly who enjoy comfortable strolls through remote sections of city parks to catch glimpses of birds and animals. These different approaches to nature study call for equipment that ranges from almost nothing extra except warm clothing to the most extensive equipment for back packing, photography and electronic surveillance.

Public and private administrators of parks and other natural areas in the Region have become increasingly interested in nature study over the last twenty years. This interest has resulted in extensive expansion of nature trails, guided tours of museums and other community activities. The recently enlarged interest in conservation and ecology will serve to reinforce this Regional trend in nature study.

FLOOD CONTROL

Average annual flood damages in the NAR, as of January 1966, were about $150 million (1970 dollars). In the absence of existing and nearly completed projects, it is estimated that this figure would have been about $240 million.

If no further action is taken to reduce flood damages, they can be expected to grow from the 1966 figure to an annual average of $900 million by 2020 as shown by Areas in Figure 16.

Up to the present, structural means of flood damage reduction have been most heavily relied on in high damage areas.

Passive or non-structural means of flood damage reduction have not been used with great success in the Region in the past. It now appears that a new awareness of the value of flood plain management techniques is emerging. More and more state and local governments are encouraging proper flood plain management and land use through education and legislation.

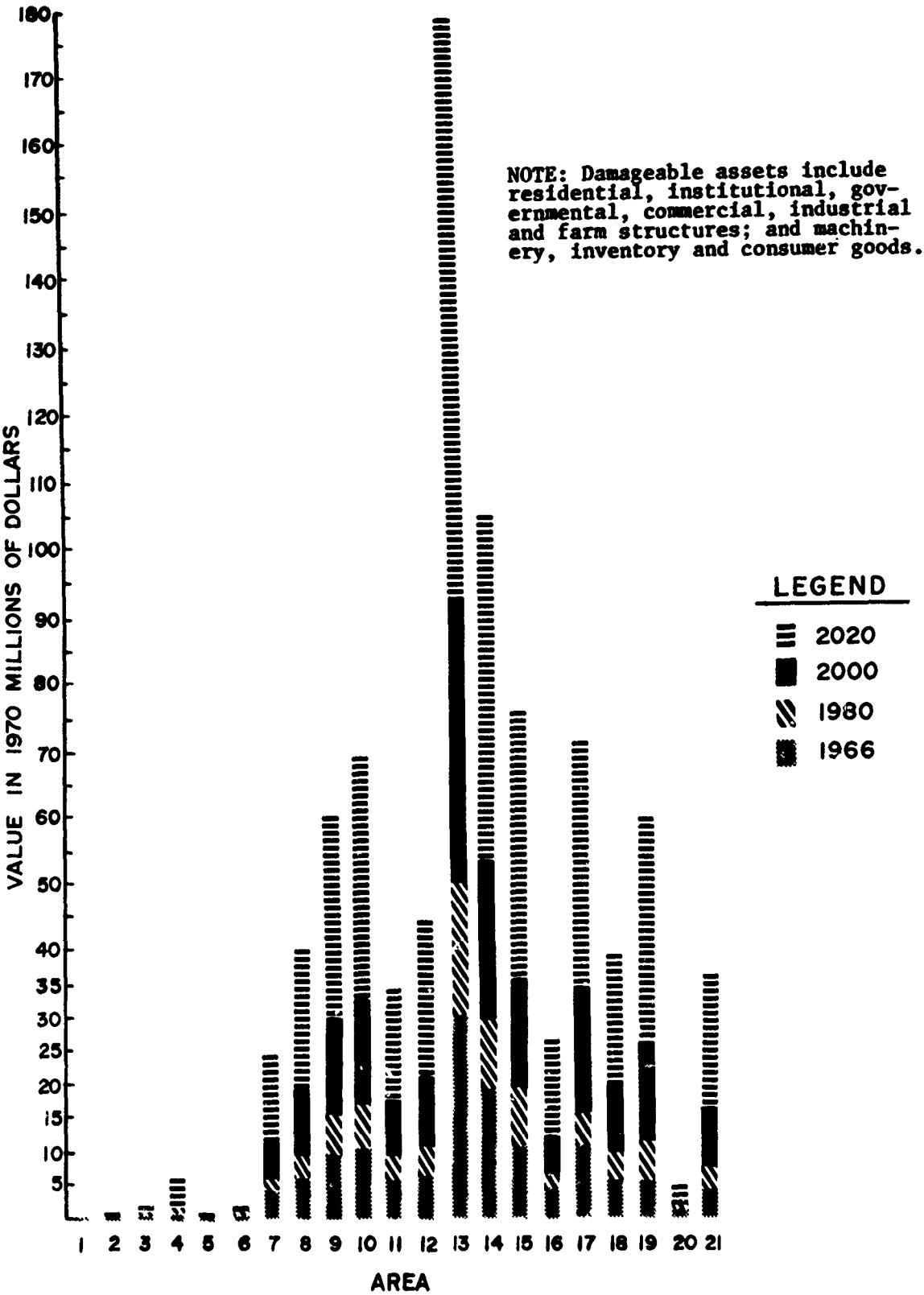
All evidence gathered during the NAR Study suggests that flood plain management will play a more substantive part in reducing flood damages in the future.

Existing projects for flood damage reduction have reduced damages in a number of Areas. Greatest reductions have been brought about in Areas 8, 9, 10 and 17, with Area 17 having by far the most notable reduction.

Tidal and hurricane flooding causes a large portion of flood damages in coastal areas. It is a serious problem, particularly in those Areas where high population and recreation pressures are stimulating development in the coastal flood plain.

About one-third of the total average annual damage from flooding in the NAR occurs in the upstream flood plains. "Upstream" refers to those streams above a point where the total area drained is less than 250,000 acres (390 square miles).

In 1966, upstream average annual damages (total damage minus reduction of authorized projects), was equal to $55 million (1970 dollars). Of this, flood water and sediment damage to agricultural crops, farmlands, and buildings amounted to $18 million and damage to nonagricultural properties amounted to $37 million. The range of average annual damage of all types was $0.06 million in Area 1 to $10.91 million in Area 18.



AVERAGE ANNUAL FLOOD DAMAGES
NAR, 1966-2020

Figure 16

Without additional flood prevention measures the annual flood damages would increase to $82 million in 1980, $145 million in 2000, and $277 million in 2020. If new construction were restricted from flood plains the damages are projected to reach $70 million in 1980, $98 million in 2000 and $150 in 2020.

Total area contained within the 100 year frequency flood plain in upstream watersheds of the Region, is approximately 6.1 million acres. The area contained in the 50 year and the 10 year frequency flood is approximately 5.6 million acres and 4.3 million acres, respectively. Of the flood plain, 34 percent is in crop and pasture, 36 percent is in forest, and 30 percent is in urban and miscellaneous.

The range of crop and pasture lands which are inundated in the various Areas is less than 1 percent in Area 5 to 50 percent in Area 17. The range of inundation in urban and miscellaneous lands is from 7 percent in Area 21 to 80 percent in Area 9. The range of inundation in forestland is from 4 percent in Area 9 to 78 percent in Area 1. The area of land that is inundated as a percent of the total land in each Area ranges from less than 1 percent in Area 1 to 48 percent in Area 18.

EROSION

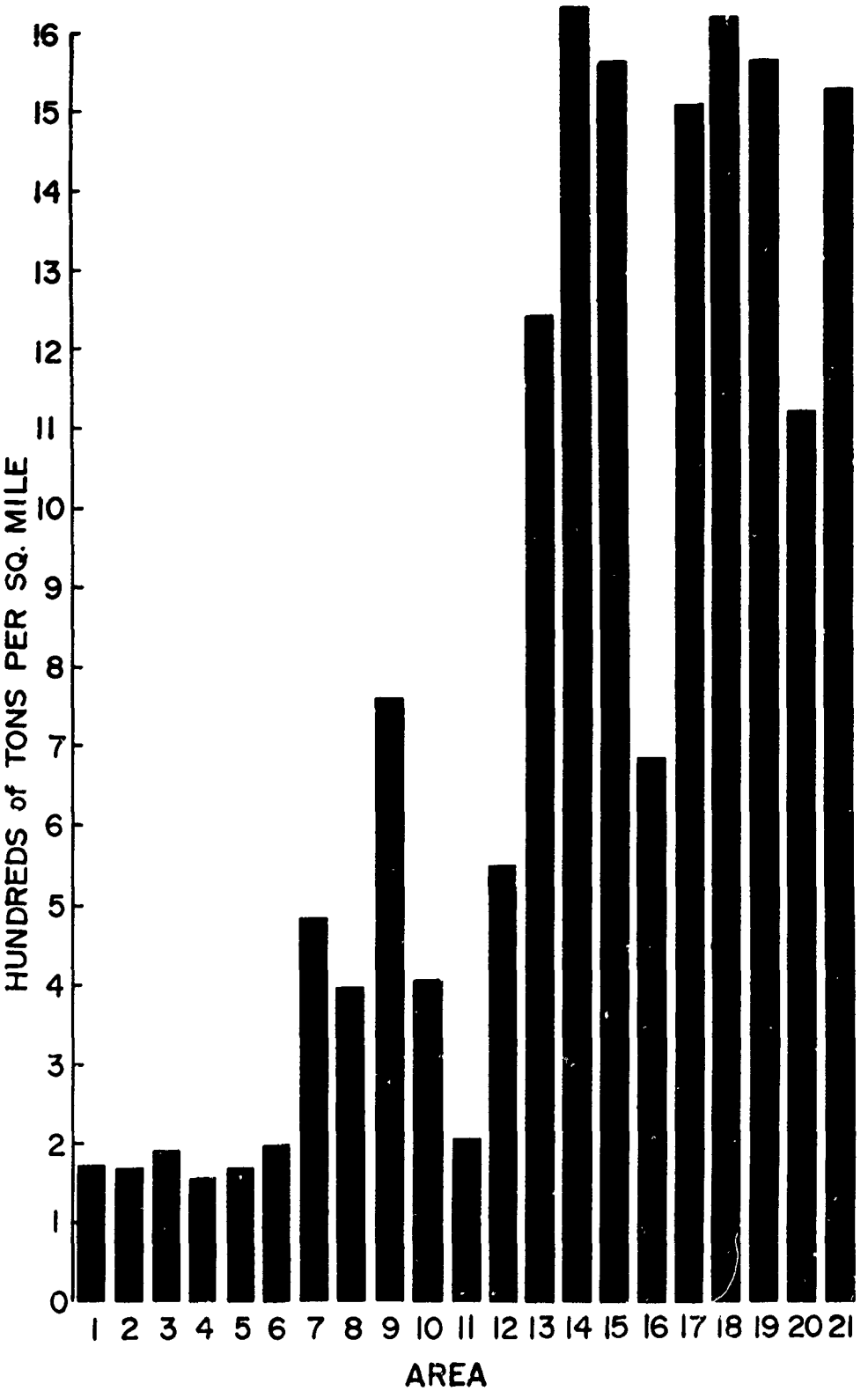
Erosion of land by water occurs either as sheet erosion, the removal of a relatively uniform layer of soil by overland runoff without formation of channels, or channel erosion, the removal of soil and rock by a concentrated flow of water in definite channels, such as gullies. Sheet erosion is the principal process at work in the NAR.

Beside the obvious damages of erosion in the loss of rich and productive and possibly irreplaceable topsoil, the resulting sediment can cause infertile overwash, swamping and increased flooding, and damage to drainage improvements, reservoirs, transportation facilities, water filtration equipment for industrial and municipal use, and fish and wildlife habitats. Suspended sediment resulting from erosion is a major water quality consideration.

The bar graph in Figure 17 shows that annual soil loss varies throughout the Region, from 154 tons per square mile in Area 4, to 1,645 tons in Area 14, depending on differences in soil type, topography, rainfall intensity, and ground cover (forest, cropland, urban, etc.). In general, both erosion and sedimentation problems are far more severe in the southern half of the Region than in the northern half.

Projected future increases in erosion rates reflect the expected land use shift from cropland and pasture to urban and other land. Urban lands have erosion rates more than five times greater than farmland, at least initially. Estimates of average erosion rates during the period of transition to urban use, range up to 75 times the cropland rate.

Coastal erosion and flooding are, in some respects, more complex problems. Storms are the principal culprits particularly in coastal areas south of Cape Cod. Tides and littoral drift -- a transporting of sand from one point on the shore to another -- can result in gross erosion. The ability of the shore to withstand wave energy varies enormously from the rocky coast of Maine on the one hand, to the silky-clay bluffs of Chesapeake Bay on the other.



RATE OF ANNUAL SOIL EROSION, NAR

Figure 17

DRAINAGE

Water drainage problems exist on 17.2 of the 105.7 million land acres in the North Atlantic Region. Of this, approximately 9.6 million acres are in forest, 5.1 in crop and pasture, and 2.5 million acres are in other land.

WATER SUPPLY

The North Atlantic Region is generously supplied with water. The annual precipitation averages from 40 to 45 inches and on a total volume basis is adequate to satisfy water supply demands. Ground waters are extensive and in many Areas are relatively undeveloped. The recent drought in the Northeast (1961-1966) was the longest and most severe in the history of the Region, with precipitation in portions of the Region averaging one inch a month less than normal for a period of about four years. The drought emergency demonstrated the inadequacy of existing facilities to properly utilize the available water resources of the Region with respect to the development of dependable sources, and the inadequacy of conveyance facilities, distribution systems and treatment plants.

Water from public or central water supply systems satisfies many needs -- domestic, industrial, commercial and municipal. In the NAR, 41,770,000 people, or approximately 88 percent, are supplied with water from some 1,200 central water supply systems. Present (1965) use averages about 5.5 billion gallons per day, of which 4.7 billion gallons per day is for domestic purposes. The population served by central water supply systems is projected to increase from the present 88 percent, to 92 percent by the year 2020, and that increase taken into consideration with the overall population increase projected for 2020 will determine the amount of total public water supply needed by that date.

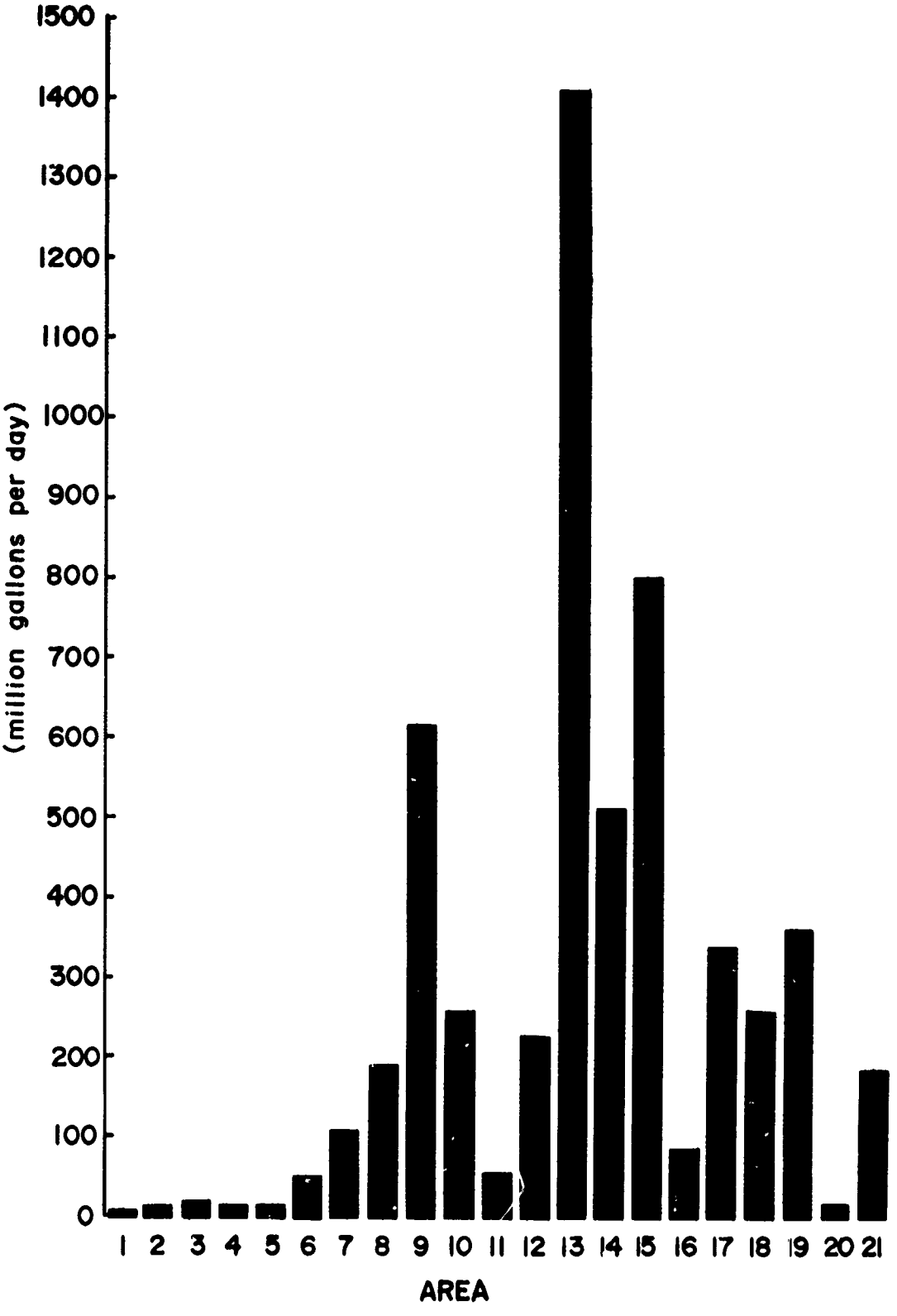
Surface waters supply approximately 7 percent of the water used by public water supply systems, with the remainder from ground water sources. Several of the Areas obtain portions of their supply from adjacent Areas by interbasin diversion. Figure 18 shows by Areas the magnitude of present public water supplies.

Self-supplied industrial water is considered to be that portion of the total industrial water intake developed by industries from their own sources, which could be fresh, brackish or waste water. The total industrial water intake for the Region is 7,340 mgd, of which 3,836 mgd are fresh water, 2,756 mgd are brackish water, 120 mgd are waste water, and 628 mgd are publicly supplied fresh water. Approximately 17 percent of the self-supplied fresh water is developed from ground water.

Table 16 shows the Region's 19 major water-using industries and lists their total use, and their use by five water supply categories. This use will increase throughout the Study period as industrial activity expands.

Livestock numbers and unit products were used to determine livestock water use. Per capita consumption and households in rural areas with self-supplied systems were used to determine rural domestic water use. The present and projected rural populations for the Region's 21 Areas are shown in Table 17. Rural domestic and livestock water use is shown for 1964 in Table 18.

Ground water is used to supply most rural water needs with the balance coming from ponds and small streams adjacent to the location of the need.



PUBLIC WATER SUPPLY, NAR, 1965

Figure 18

TABLE 16
NAR INDUSTRIAL WATER
WITHDRAWALS, 1965

Industry	Total Use	Self-Supplied Fresh	Publicly Supplied Fresh	Waste Water	Brackish Water	Fresh Consumption
			(million gallons per day)			
Chemicals & Plastics	2,362	1,039	159	0	1,165	193
Primary Manufacturing	1,675	770	63	120	722	207
Paper	1,166	1,027	41	0	97	91
Petroleum	740	206	12	0	523	25
Food	392	157	85	0	150	38
Transportation Equipment	266	196	70	0	0	15
Machine Equipment	142	97	42	0	3	8
Glass & Clay	130	81	10	0	39	34
Fabrics	120	84	25	0	12	13
Electrical Equipment	97	53	43	0	0	8
Rubber	91	40	13	0	39	7
Metal Products	72	41	31	0	0	5
Scientific Instruments	40	22	18	0	0	3
Leather	16	7	2	0	6	3
Miscellaneous Manufacturing	13	7	6	0	0	1
Apparel	6	3	3	0	0	1
Tobacco	5	3	2	0	0	0
Printing	4	2	2	0	0	0
Furniture	2	1	1	0	0	0
Wood Products	1	1	0	0	0	0

TABLE 17
RURAL POPULATION
BY NAR AREAS, 1964-2020

Area	1964 1/	1980 2/	2000 3/	2020 3/
	(thousands)			
1	71	71	76	80
2	40	39	34	23
3	37	34	35	34
4	14	14	13	13
5	62	62	69	72
6	89	93	101	83
7	56	50	39	32
8	234	244	252	210
9	141	114	142	88
10	343	356	352	265
11	176	173	162	160
12	579	622	644	485
13	375	411	312	155
14	263	257	274	220
15	721	918	1,077	987
16	44	49	52	56
17	735	750	751	680
18	539	618	778	869
19	700	946	1,128	1,110
20	170	196	254	347
21	355	425	506	596
NAR	5,744	6,442	7,051	6,565

1/ Daily per capita use=55 gallons
2/ Daily per capita use=74 gallons
3/ Daily per capita use=95 gallons

TABLE 18
LIVESTOCK AND RURAL
DOMESTIC WATER
REQUIREMENTS, 1964

Area	Use
	(million gallons per day)
1	3.9
2	2.7
3	3.0
4	1.5
5	4.1
6	5.8
7	4.8
8	15.9
9	9.2
10	21.4
11	17.1
12	41.4
13	20.7
14	15.4
15	49.8
16	3.0
17	61.9
18	35.4
19	48.4
20	10.9
21	22.0
NAR	398.3

WATER QUALITY

The waters of the North Atlantic Region receive wastes containing a wide variety of pollutants. The resulting degradation of the waters can prohibit recreation, increase the cost of water treatment for domestic or industrial uses, impair the survival of fish and wildlife, destroy aesthetic values, cause corrosion of structures exposed to water and generally make the receiving waters less usable to man and his environment. These polluting substances can be classified in seven general categories: 1) oxygen demanding wastes, 2) infection agents; 3) plant nutrients; 4) heat; 5) organic chemicals; 6) sediments; and 7) other mineral and chemical substances.

Presently, about 2,300 known municipal, institutional and Federal sources in the NAR discharge wastes which exert a biochemical oxygen demand equivalent to untreated waste from a population of approximately 16,400,000. Of the total Regional population, 83 percent, or 36.8 million persons, were served by waste water collecting systems. Of this population's waste water, about 12 percent was discharged to receiving water untreated, 48 percent was given at least primary treatment, and 40 percent was given secondary treatment or better. The primary treatment settles out both organic and inorganic solid material suspended in the waste water flow while the secondary treatment biologically removes organic material dissolved in the waste water flow. The remaining 17 percent of the Region's population was either using individual disposal systems such as septic tanks and cesspools (6.0 million persons) or had to be classified as unknown (1.8 million persons). Table 19 presents the estimated present non-industrial discharges, for the Region as a whole.

Industrial discharges, consisting of wastes from all the major water using industries contribute waste equivalent to the untreated waste from approximately 40,000,000 people in terms of biological oxygen demand or about 70 percent of the total discharged load. The pulp and paper industry accounts for approximately 35 percent of this waste load. The waste loading by industrial groups of water-using industries is shown in Figure 19. Both industrial and non-industrial organic waste load projections are given in Table 20. The 800 percent increase projected for industrial waste loads to 2020 and the amount of treatment necessary for these loads illustrates the importance water quality maintenance in industry will have in future water resources development plans.

In addition, industries such as the chemical, petroleum, paper, primary metals and mining operations which produce inorganic wastes discharge to the Region's waters.

Storm water and municipal wastes are presently collected, transported and discharged through at least 337 combined sewer systems within the Region. These systems serve an estimated population of 17.2 million persons or approximately 45 percent of the Region's entire sewered population. Those metropolitan areas having the largest concentrations of people and the oldest wastewater collection systems have the most acute problems with these systems. The huge loads placed on sewage treatment facilities during periods of high runoff due to rainfall is a major problem. Data are unavailable to accurately estimate the amount of waste water discharged by these systems. In this study it is assumed that combined sewers will decrease through the planning period.

TABLE 19
ESTIMATED NON-INDUSTRIAL DISCHARGES
AND THEIR TYPE OF TREATMENT FOR NAR*

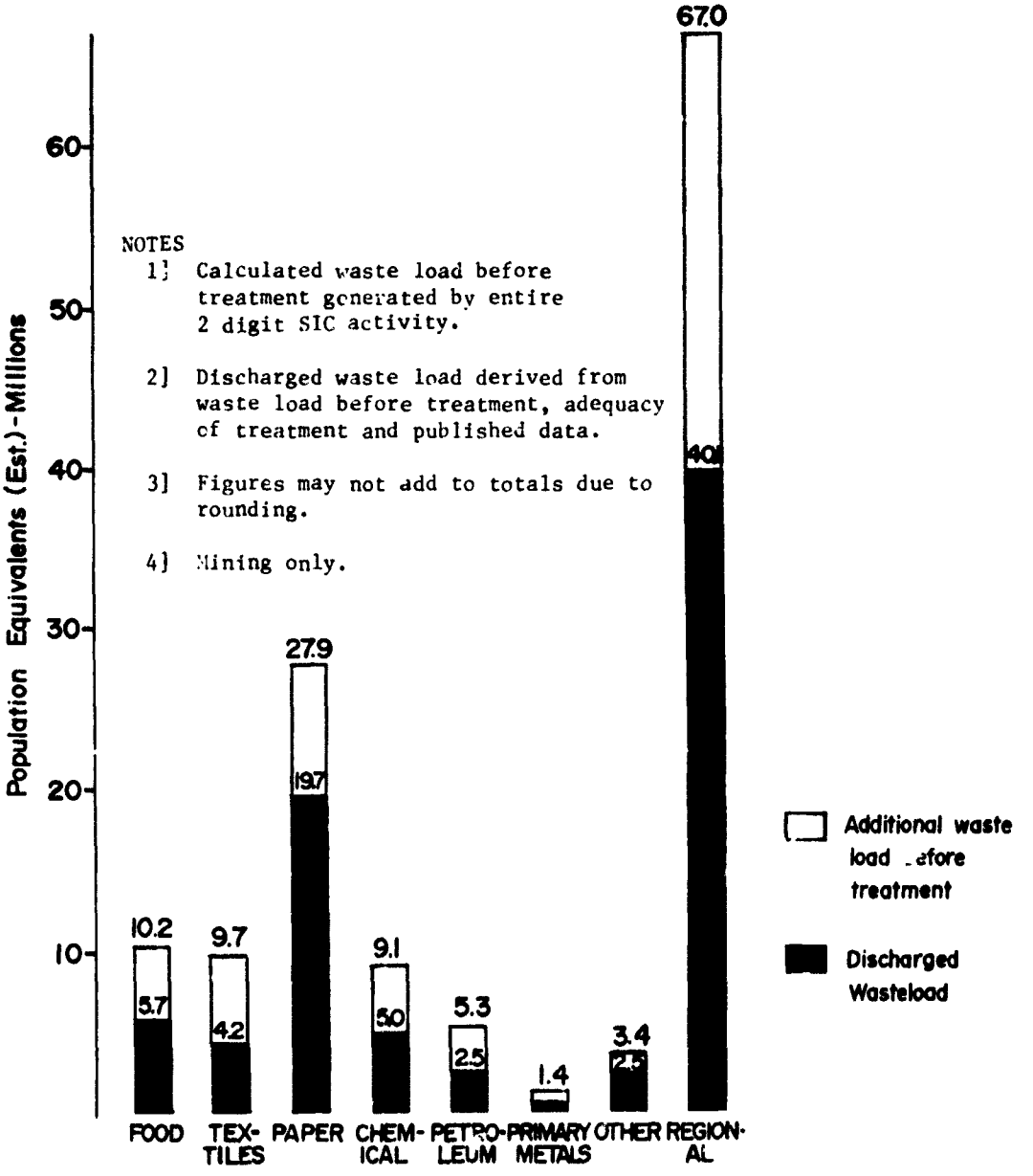
	Number of Systems	Population Served	Waste Load Discharge
		(thousands)	(P.E. thousands) 1/
NAR Total	2,320	36,800	16,400
Degree of Treatment			
Unknown	89	219	-
None	815	4,360	4,360
Primary	644	14,600	8,690
Intermediate	54	2,530	1,010
Secondary	706	15,000	1,940
Adv. Waste Treatment	10	17	-
Systems Overloaded (outdated)	113	5,360	
Systems Not Chlorinating	820	9,900	
Combined Storm Sewer Systems	377	17,200	

1/ PE, or the population equivalent, is a means of expressing the strength of organic industrial waste in terms of an equivalent number of persons. Domestic wastewater consumes an average of .17 lbs of oxygen per person per day as measured by standard BOD tests. For example, if an industry discharges 1700 lbs of BOD per day its PE then equals 10,000.

* Present waste loads were obtained from previously prepared studies and reports, generally covering the period 1960-1967.

ESTIMATED INDUSTRIAL WASTES and ADEQUACY of TREATMENT, NAR

(from reports and inventories generally between 1960 and 1967)



(NUMBER OF SOURCES)[3]							ADEQUACY OF TREATMENT
138	216	107	70	16	167	714	NONE
221	31	80	79	17	45	473	PARTIAL
19	7	7	23	2	5	63	COMPLETE
64	22	19	32	8	24	169	UNKNOWN
442	265	220	199	32	241	43[4] 1442	NUMBER OF KNOWN SOURCES

Figure 19

TABLE 20
ORGANIC WASTE LOAD
FOR NAR, 1960-2020

		1960	1980	2000	2020
			(1000's of PE)[5/]		
Non-Industrial[1/]	B.T.	43,800[4/]	55,700	69,800	86,600
	A.T.[3/]	16,300	8,360	7,820	9,760
Industrial[2/]	B.T.	67,100	144,000	303,000	624,000
	A.T.[3/]	40,000	21,600	31,900	65,800
NAR	B.T.	111,000	200,000	373,000	710,000
	A.T.[3/]	56,800	29,900	39,800	75,600

B.T. = before treatment
A.T. = after treatment

1/ Includes waste loads from municipalities, institutions and Federal installations.
2/ Includes waste loads from the six major water-using two digit SIC groups.
3/ This is considered to be a result of actual treatment practice in 1960 and the secondary treatment for 1980, 2000 and 2020.
4/ Includes 5,956,000 persons not served by non-industrial waste collection systems.
5/ For the definition of PE, see Table 19.

Within the Region there are more than 2.4 million separate housing units, as well as an unknown number of business establishments, which dispose of waste through septic tanks or cesspools. As the densities of the Region's localized populations increase, these individual disposal systems will become increasingly unsatisfactory. Second home ownership for weekend and vacation use is a major cause of this problem.

It is expected that through the planning period there will be a significant drop in the percentage of individual systems in relation to the total sewered population. Notable exceptions will be recreational centers in rural areas.

The effects of acid mine drainage on water bodies are critical in the Lehigh and Schuylkill Rivers of the Delaware River Basin (15) and in various tributaries of the Susquehanna Basin (17). The Commonwealth of Pennsylvania has initiated a program attempting to control acid mine drainage in Pennsylvania.

The most significant sources of thermal pollution in the NAR are nuclear and thermal electric power generating plants. It is expected that significant increases in thermal loadings will occur during the planning period because of the anticipated rise in population and electrical power requirements. This pollution load will depend on the ability of designers to tailor new plants to meet established water quality criteria and standards.

Thermal pollution from manufacturing will increase due to a projected rise in employment (and consequently, new plants) in the chemical and primary metals industries.

Over 700,000 small craft are registered in the NAR. Recreational boating constitutes a source of pollution because of the potential for the discharge of human fecal matter, litter, motor exhaust and oil. The disposal of waste and the spillage of oil from commercial craft in the major ports of the NAR also contribute localized pollution effects.

Monitoring, such as this sampling of bottom deposits in New York harbor, must be expanded to understand the extent of Regional water pollution. (Environmental Protection Agency).

The coastal waters of the NAR receive untreated or partially treated waste loads from municipalities and industries located along the coast. The waters offshore of Boston, New York, and Cape May have long been used as disposal sites for rocks, mud, dredging spoil, sewer sludge, and industrial wastes. Considerable study of the effects of disposal of these materials upon the ocean's biota is needed to determine the environmental impact. Over 15.4 million cubic yards of these materials were dumped in the New York Bight in 1966. The dumping of exotic materials off the Boston coast has temporarily been suspended since February 1970. Unless alternative methods of ultimate disposal are found, it is certain that the amount of wastes disposed of in the ocean will increase significantly through the planning period.

Urban runoff will become more significant in the NAR as more land is developed and is made impervious to precipitation. In addition to the quantities of urban runoff which affect the surface waters, the composition of the runoff is distinctive. Urban runoff may contain oils, organic matter, trash, inert solids, salts, fertilizers and whatever else can be easily swept or washed into street gutters, storm sewer systems or the nearest water course. Those portions of the NAR which will undergo massive urban development through the target years will experience greatly increased waste loadings from urban runoff.

The physical disturbance of the soil cover by construction activities for both buildings and roadways is and will continue to be of significance in the NAR. Sediment loadings to the streams become significant in the estuaries and harbors; in the Susquehanna River alone, sediment discharge measurements indicate an annual load of three million tons of suspended sediment.

ENERGY

Electric power consumption increases in proportion to higher income, population and technological progress. New technology markets and increased leisure time will increase demands for new forms of basic and luxury appliance items, recreation, newer, cleaner methods of heating, transportation and environmental control. The NAR will probably continue to demand and use over 20 percent of the national electric load throughout the planning period, with increases in the Region being based on industrial and population projections.

In 1968, principal utilities, constituting only 21.5 percent of the total number of systems, accounted for 97.8 percent of market energy requirements. Power production by the private ownership sector of the industry was 95 percent of the total.

The megalopolis from Washington to Boston is expected to continue to be the most concentrated load area of the Region. The availability of coastal waters as a source of cooling for industry, as well as for large electric generating stations, is one of the main reasons the megalopolis area will continue to experience considerable growth. Power requirements were 243,300 gigawatt hours in 1968 for the NAR from all classes of power users: rural, residential, commercial, industrial and all others. Those requirements were 80 percent of the general market area within which the NAR lies. It is estimated that the market load will increase to 625,000 gigawatt-hours of energy and 116 gigawatts of capacity by 1980, and 4,863,000 gigawatt-hours and 856 gigawatts respectively by 2020.

In 1968, 83.6 percent of power generation was supplied by fossil steam facilities. Almost 7 percent of the power was provided by conventional hydroelectric generation systems used primarily to supply the peak portion of power demands.

The most important facilities for thermal power base load generation are based on both fossil and nuclear fuels. Before it can become a significant force in power supply, atomic power generation must overcome problems associated with possible environmental pollution. The move from conventional to more "exotic" forms of generation, such as controlled thermonuclear fusion, catalytic fuel cells, or solar energy, may initially be more costly, but will probably have a more beneficial effect on water and air quality.

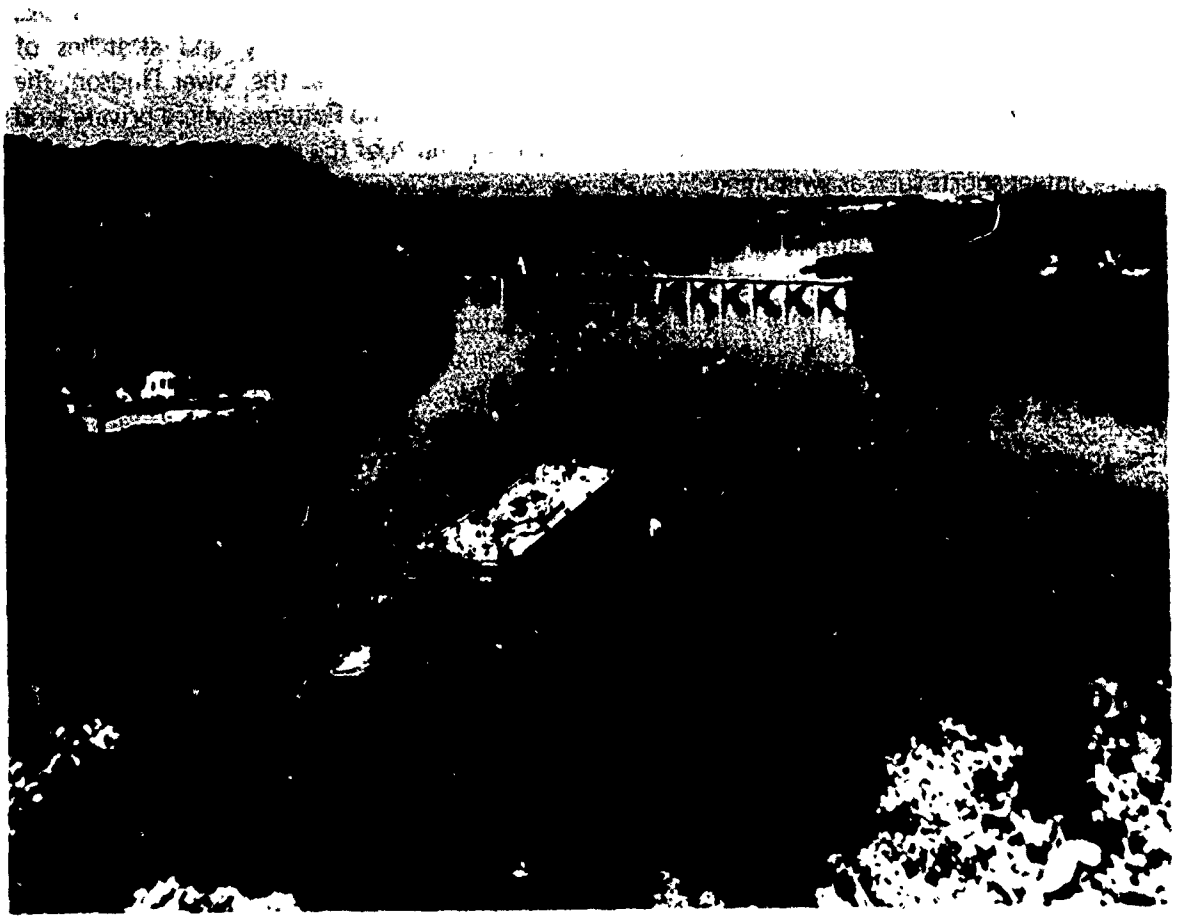
NAVIGATION

The primary methods of transportation of people and goods throughout the NAR have changed from coastal sailing ship and horse carriage to supertanker, pipelines, jumbo jet and high speed super highway. The facilities servicing those modes of travel cover most of the land included in transportation and "other" land uses. The extent to which "other" land uses exist in the NAR ranges from 1 percent in Areas 1, 2, and 3, in heavily forested Maine, to 14 percent in Areas 16 and 18, both of which include large metropolitan areas, for a Regional average of over 6 percent.

Ships carrying goods to ports in the NAR have increased in capacity from 30,000 DWT (dead weight tons) after World War II, to 100,000 DWT. There are larger ships, but the NAR harbors are not deep enough to pass such deep draft vessels. With improved port facilities, waterway improvements and the possible addition of offshore facilities, the NAR ports could handle 125,000 DWT carriers and possibly 300,000 DWT ships by 1980. Even larger petroleum tankers of up to 500,000 DWT could be utilizing eastern ports and facilities by 2020.

Daily tidal variations, ranging from two feet in the southern NAR to eleven feet in the north, affect the potential of a port. A wide range can permit larger vessels to pass at high tide than would otherwise be the case, but also introduces powerful tidal currents, complicating ship handling. Other restrictions on port use include weather (early freezing, ice floes, and fog in the north, hurricanes, etc.), and previous development around waterways (narrow channels, shallow draft shore facilities, bridges and tunnels, etc.). Without waterway improvements, barges plying the shallow waterways are not expected to increase in draft or cargo capacity over the next fifty years because of the problems experienced in maneuvering larger vessels.

Total foreign and domestic water borne commerce in the NAR increased from approximately 470 million tons in 1955 to almost 510 million tons in 1968. The four major bulk commodities of metallic ores, coal, crude petroleum and petroleum products comprised about 79 percent of all waterborne tonnage in 1966. General cargo accounted for only 13 percent of the volume by weight, but 68 percent of the $40 billion value of the total tonnage. Projections for the various cargoes are dependent upon many variables, but basically on the industrial growth of the Region and on the sectors of the Nation's economy it services, on import quotas and foreign and domestic trade policies, and on the development of facilities to handle deeper draft vessels and containerized operations.



A contrast of two eras in the North Atlantic Region's commercial navigation activity is reflected in this Mohawk River scene. A modern oil barge and tug approach a bridge which has masonry arches that originally were part of an aqueduct which carried the Erie Canal across the river. The location is at Rexford, N.Y. (New York State Department of Commerce).

The resource base for recreational boating is primarily the protected areas of estuaries and embayments, the waterways such as the Intra-coastal Waterway, and lakes and reservoirs of adequate surface area. There are six million acres of protected recreational boating waters in the Region which is equivalent to half an acre for every family now living in the NAR. The limitation for boating is not congested water surfaces as such, but inadequate shoreline facilities (launching ramps, parking lots, comfort stations). Development of these facilities and the growth and affluence of the NAR population are the two main determinants of recreation water travel during the planning period.

The major concentrations of population in the NAR are located near coastal waters and estuaries and the importance of boating as a form of water recreation is enhanced by this locational convenience. The polluted condition of waters near major population centers is less of a constraint on boating than on water-contact sports such as swimming.

Boating contributes to pollution, in the forms of oil and gasoline spillage and discharge of untreated human wastes.

RECREATION

The use of recreational areas in the North Atlantic Region has become very heavy, limiting enjoyment of the available facilities. This strain on the Region's recreational resources has been brought about by easy access to most of the inland and coastal recreational facilities; ever increasing mobility of the expanding population; larger disposable incomes; and a shorter work week.

In analyzing recreational resources of the Region, participation in seven activities were dealt with in the NAR Study; included were five water-dependent activities (boating, canoeing, sailing, swimming and water-skiing) and two water-enhanced activities (picnicking and camping). Table 21 gives estimates of the days of participation for these seven activities in 1965.

The resource base ranges from extremely plentiful in northern New England (Maine in particular) to very deficient in highly populous Area 13. Two other sections where deficiencies exist, though considerable undeveloped land is available, are Pennsylvania's Area 17 and most of Virginia. Recreational opportunities are restricted because of a lack of Federal and state recreation areas. Lack of access also presents problems in some Areas, such as Chesapeake Bay and stretches of various rivers such as the lower Hudson, the Delaware and the Potomac where private land takes up much of the shorelines.

The northern half of the Region not only has more present and potential facilities, it also has by far the largest participation in every recreational activity investigated in the NAR. The population is high and facilities are extremely accessible with a high use density. The superior transportation network of this portion of the Region makes more activities readily accessible to recreators.

The most popular water recreation activity throughout the NAR has been swimming, whether it be in the inland pools, lakes, ponds, reservoirs, creeks or streams, or the extensive, attractive and well developed coastal facilities. Recreators by the million flock to the beaches in Virginia, on the Delmarva peninsula, the Jersey Shore, Long Island and Cape Cod. Coastal beaches and other swimming facilities farther north also offer numerous opportunities, even in northern Maine for hardy enthusiasts.

TABLE 21
PARTICIPATION IN
OUTDOOR RECREATION
FOR NAR, 1965*

Activity	Days of Participation by Census Regions		
	New England	Mid-Atlantic	South Atlantic
	(days per person)		
Boating	2.71	0.93	1.15
Sailing	0.62	0.15	0.15
Canoeing	0.19	0.11	0.17
Water-skiing	0.75	0.13	0.24
Swimming	11.33	7.45	6.02
Camping	0.66	0.23	0.37
Picnicking	4.82	2.75	2.55

* Days of participation per person 12 years and over in selected outdoor recreation activities for the 1965 summer season by census regions.

Innumerable bodies of inland flat waters, especially the larger developed lakes such as Moosehead, Winnesquan, Champlain, Sebago, Wallenpaupack and Winnepesaukee offer opportunities for many recreational activities. Shown in Table 22 are water surfaces by NAR Areas. Comparing water surfaces among the Areas gives an indication of potential water recreation. Boating and related activities on these surfaces, as well as along the coast, are third on the list following picnicking.

The wilderness covering almost a quarter of New England and the major rivers such as the St. John, Kennebec, and Penobscot which flow from these wildernesses offer hundreds of miles of white water canoeing. The New England climate is also extremely amenable to recreators providing both warm beaches and cool mountains within a few hours' drive of each other.

Additional forests and state parks provide great opportunities in the NAR. Camping in these facilities has become very popular as people wish to set up close to other recreation activities. The larger parks such as the White Mountain and Green Mountain National Forests, Acadia National Park, the Adirondack and Catskill Forest Preserves, George Washington National Forest and Shenandoah National Park, through which runs the famous Appalachian Trail, are augmented by hundreds of state parks and preserves which provide facilities to the public for almost every type of recreation activity.

Accompanying the problem of access to recreation in the Region is the problem of pollution. Even in the northern Areas with large amounts of wilderness the lower reaches of rivers are polluted from municipal and industrial waste.

An Area which reflects all of the problems faced by recreators is Area 13. Industrial and municipal pollution have fouled facilities which were made inadequate because of the extent of development for purposes other than recreation. A great many recreators in this and similar population centers must travel to other areas to find adequate facilities. This influx then puts pressure on the facilities they visit.

However, over-all there are large amounts of recreation resources in the NAR. Unfortunately there is an overabundance in some Areas and deficiencies in others. Competition from other land uses also threatens this already poorly distributed resource base. Private facilities do not make up the difference anywhere.

TABLE 22
WATER SURFACES
BY NAR AREAS

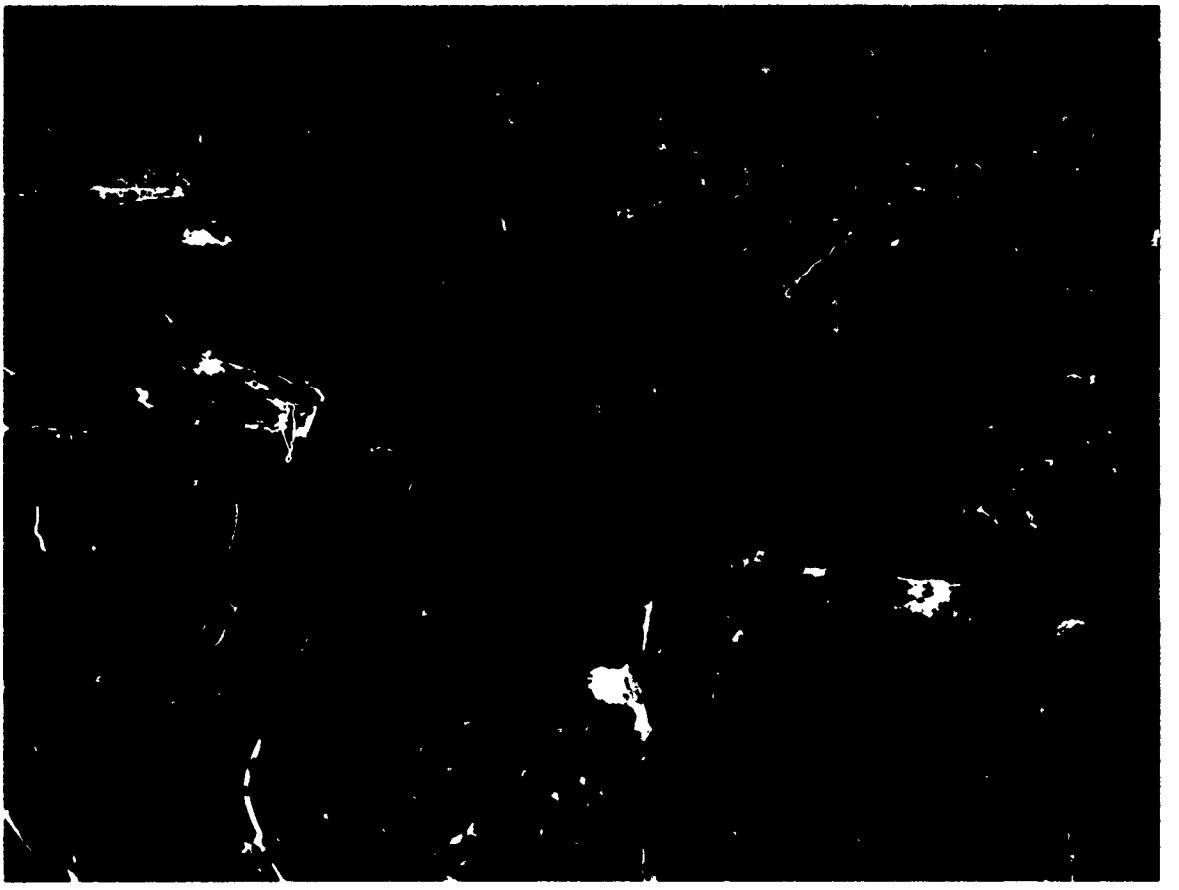
Area	Small Surfaces 1/	Large and Intermediate Surfaces 2/	Total
	(square miles)		
1	15.6	201.6	217.2
2	31.2	593.8	625.0
3	10.9	273.4	284.3
4	20.3	128.1	148.4
5	12.5	804.7	817.2
6	23.4	321.9	345.2
7	31.2	212.5	243.7
8	65.6	200.0	265.6
9	43.8	440.6	484.3
10	43.8	118.8	162.6
11	68.8	675.0	743.8
12	59.4	348.4	407.8
13	1.6	254.7	256.3
14	12.5	62.5	75.0
15	79.7	239.1	318.8
16	3.1	189.0	192.1
17	117.2	195.3	312.5
18	45.3	834.3	879.6
19	40.6	165.6	206.2
20	15.6	146.9	162.5
21	21.9	204.7	226.6
NAR	764.0	6,610.9	7,374.9

1/ Surfaces under 40 acres
2/ Surfaces over 40 acres

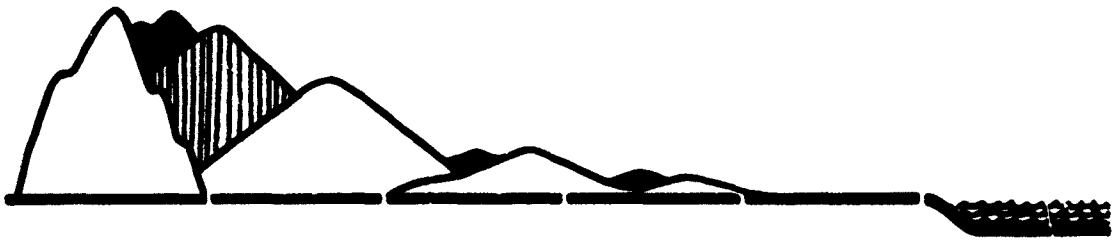
VISUAL

Landscape resources while largely subjective to each individual, are no less important than the more tangible, objectively measurable assets of the Region. Visual resources relate to the lifestyles of the people of the NAR, and the ways in which these lifestyles are affected by available landscapes. Landscapes may be analyzed from two interacting points of view the nature of the land form or topography (mountains, rolling hills, coastline, and the like), and the type of human use of the land and other resources (center city, farm, forest wildland and interfacing combinations of these). The land forms have been classified into Landscape Series and the human use into Landscape Units. Figure 20 shows these classifications.

In general, water is an important element of visual landscapes. Bodies of water greatly augment the visual appeal of other physical elements of scenery and except when grossly polluted, are almost never out of place. The dominant land forms in the Region are mountains, steep hills, and rolling hills, which together cover four-fifths of the study area. Mountains and steep hills tend to be almost entirely forested with little or no human development, while rolling hills, which alone cover almost half of the NAR, show the full range of development from wilderness to central city. The coastline landscapes of the entire Region, and particularly Maine, are one of its most outstanding visual resources.



This Merrimack River Basin [illegible] -- farm-town, farm-rest, and [illegible] -- [illegible] development, commercial, homes, [illegible] appear [illegible] Division, [illegible].



MOUNTAIN | STEEP HILL | ROLLING HILL | UNDULATING LAND | FLAT LAND | COASTLINE

A - LANDSCAPE SERIES

CENTER CITY | INTER-MEDIATE CITY | FRINGE CITY | TOWN FARM | FARM | FARM FOREST | FOREST TOWN | FOREST WILDLAND

B - LANDSCAPE UNITS

CLASSIFICATION OF NAR LANDFORMS (A) AND LANDSCAPE PATTERNS (B)

Figure 20

Farmland has a visual influence on 38 percent of the NAR, and dominates in 15 percent of the Region while cities, suburbs, and towns exert an influence on about one-third of the Region. One-fourth of the Region includes mixed landscapes of towns and forests, or towns and farms, and important vacation centers are often found in these visually rich and varied areas

The landscape units which have the greatest percentage of land in the Region and are highly valued, are Forest-Town (40.2 percent) and Forest-Wildland (28.1 percent). These units include essentially all of the major inland recreational areas in the Region; the lake area of Maine, the Lake Winnepesaukee district in New Hampshire, the Poconos in New York and part of the Blue Ridge in Virginia. They all fall within the Forest-Town unit. Often major vacation and recreation areas such as the White, Green and Adirondack Mountains fall within the Forest-Wildland pattern. The latter pattern also has the single largest percentage of its area having low value. Continuous forest landscape, as often found in this Forest-Wildland pattern, can be monotonous when it is uninterrupted by town, lake, bog or river.

The geographic distribution of different landscapes, both quantitatively and qualitatively, is an important additional dimension in evaluation. First is the consideration of the juxtaposition of different landscapes or the contrast between landscapes. This is the visual diversity created between landscapes rather than within a landscape. The diversity between landscapes is created, for example, by three contiguous landscape images such as Forest-Town, Forest-Wildland and Town. Within a landscape, diversity is created by the relationship of elements such as land form, vegetation, structures and water.

All of the areas listed in Table 23 have several characteristics in common. They all encompass a range of three landscape series and three landscape units within two and a half hour's driving time from major metropolitan centers. Also, all of the areas contain at least one of the farm units. Open land also provides opportunities for views to the hills and mountains which are not available across covered lands. The juxtaposition of different land forms and different patterns which, while not of high quality on the basis of individual components, creates composite landscapes of diversity and high quality. These areas of composite landscapes (Table 23) cover approximately 20,400 square miles, or twelve percent of the Region. These areas represent on a large scale, though there are many areas on a smaller scale, the best of the Regional image of landscape diversity which must be maintained.

The coastline of the NAR, for essentially its entire length, also falls within the concept of composite landscapes. The very sharp edge which is created by the coming together of land and water combined with the immediately adjacent landscape series (which range from steep hills in Maine to flat land in Virginia) and landscape units (all units are found adjacent to the coastline) creates composite landscapes which are almost universally recognized as of high quality. Within this series, however, (more so than any others) is to be found the greatest number of landscape misfits -- products of insensitive development of coastlines in and around all major cities. Greater emphasis on preservation of the shoreline's exceptional visual landscape resource, especially along the eastern Maine coastline which has a low threshold of tolerance of human activity, is necessary to maintain the visual quality of the sharply contrasting resource. Development of these areas by competing land uses will have to be controlled or curtailed.

TABLE 23
LOCATIONS IN NAR WITH
COMPOSITE QUALITY LANDSCAPES

Location	Square Miles	Evaluation Factor
Lake Winnipesaukee, N.H.	1200	Juxtaposition of Forest-Wildland, Forest-Town and Farm-Forest Units.
Connecticut River, Southern Vt. and Massachusetts	800	Juxtaposition of Town-Farm, Forest-Town and Forest-Wildland Units.
Lake Champlain Valley, Vermont and New York	4400	Juxtaposition of Farm, Town-Farm, and Forest-Wildland Units.
Northern Adirondack Area, New York	1200	Juxtaposition of Town-Farm, Forest-Town and Forest-Wildland Units.
Mohawk River Valley, New York	2400	Juxtaposition of Farm, Town-Farm and Forest-Wildland Units.
Southern Catskill-Poconos Area, NY, NJ, and Pa.	2400	Juxtaposition of Farm, Town-Farm & Forest-Wildland Units.
Great Valley-Blue Ridge Mt. Area, Va. & W. Va.	8000	Juxtaposition of Farm, Forest-Town and Forest-Wildland Units.
Coastline-Maine to Va.		Juxtaposition of the land-water edge with varying Series and Units.

Another factor, and one of major importance in the consideration of the geographical distribution of landscape series and units, is the relationship of quality landscapes to the major population centers of the Region. One of the greatest Regional problems related to the visual environment is the fact that the esthetically richest areas of the NAR are located at considerable distances from the greatest center cities and urban concentrations, which contain the bulk of the Region's population.

HEALTH

Health needs are important because of the size of water supplies that are necessary to satisfy the demands of a highly concentrated populace.

Whenever people use water they are affected by whatever pollution or insects are present in it and are, thus, vulnerable to any diseases carried by these sources. However, the NAR has no abnormal pattern of disease incidence, so that the health effects of water upon the people of the NAR are proportionally the same as those effects of water on the entire United States. Approximately 25 percent of the Nation's population resides in the NAR, and these people had 25 percent of the total cases reported for the six diseases included in the Morbidity and Mortality tables supplied by the U. S. Public Health Service Communicable Disease Center. The NAR distribution of these diseases is shown in Table 24.

TABLE 24
REPORTED CASES OF POTENTIALLY WATERBORNE HUMAN DISEASES IN NAR, 1965-1968

Disease	1965	1966	1967	1968	Four Year Total
Amebiasis	1,329	1,403	1,837	1,786	6,355
Encephalitis	695	615	512	360	2,182
Hepatitis	7,496	7,234	9,314	11,066	35,110
Salmonellosis	4,816	5,106	4,390	4,767	19,079
Shigellosis	1,453	2,318	2,779	2,559	9,190
Typhoid Fever	73	87	57	65	282
Total	15,862	16,763	18,889	20,603	72,117

These figures illustrate Regional trends, but it must be noted that they represent those diseases which could be waterborne and are not those which are positively identified as waterborne or even linked in some of these cases as definitely being waterborne; though some incidents positively are connected. Some of these diseases, for instance, can also be attributed to being carried by food. Reporting procedures are not uniform. Still other diseases may be waterborne which have as yet not been identified as such.

Some cases can be positively identified such as encephalitas outbreaks, where mosquitoes have been shown to be carriers, or the consumption of clams from a particular area causing hepatitus, or a particular contaminated drinking water supply, or a polluted bathing facility. Reliable and intensive investigations and reporting procedures are required to obtain better information on which to base the health aspects of the development of water and related resources.

CHAPTER 4

AVAILABLE WATER AND LAND RESOURCES

WATER

The resources available to the planner in any specific Area must be defined in greater detail than possible in a general description of the Region. This Chapter describes the water and related land resources of the NAR and the degree these resources can be developed to meet demands made upon them.

The Hydrologic System

In considering the available water resources, surface and ground water cannot be thought of as separate or distantly related sources. Ground water and surface water are in fact two parts of the same system, and withdrawal of water from one of these sources will, in many instances, merely subtract from the water available from the other source.

In humid regions such as the NAR, overland runoff to streams usually ceases within 3 or 4 days after a storm, and is commonly lost to the system as high or flood flow. Most streams and rivers in the NAR continue to flow in ensuing periods of no rainfall, however, fed by seepage from the ground-water reservoir. Lacking this contribution from ground water, rivers such as the Connecticut, Hudson, Delaware, Susquehanna and James would be dry for long periods every year

During periods of rainfall or rapid snowmelt in the NAR, the rate of natural recharge to the ground-water reservoir is greater than the outflow from that reservoir to the streams. Thus, the water table in interstream areas rises during periods of high rainfall and declines slowly during periods of lesser or no rainfall.

Presently Available Water Resources

Estimates of the water resource presently available in an Area are based on the minimum streamflow plus an adjustment for the flows not reflected in stream gaging records. Stream gaging records reflect: the natural stream flow, return flow from ground water development; regulation by existing reservoirs; and transfer of water from or into an Area. The adjustments are corrections for. consumptive losses incident to existing water uses; transfers between basins, ground water used but not returned to the Area's streams above the points of measurement, and certain reservoirs under construction.

The minimum flow adopted in this Study was developed on the basis of an analysis of existing monthly and daily streamflow records. It is that average 7-day flow that corresponds to a monthly low flow having a shortage index of 0.01. This shortage index indicates that, on the average, there can be expected in 100 years one shortage period with a 10 percent shortage; or two shortage periods of 7 percent severity; or one period of 7 percent and three periods of 4 percent or similar combinations of shortages. The low flows established under this shortage index of 0.01 are approximately equivalent to the 7 day low flows having a recurrence interval of 50 years.

Summarized in Table 25 are the estimates of minimum streamflow for each Area as well as the presently available resources. In the case of the latter, adjustments have been made so as to include estimated 1965 consumptive losses; allowance, in originating Areas, for yields of reservoirs used for interbasin transfers; and, in the case of Area 13, outflow of developed ground water. Available resources also include allowances for the effects of the Beltzville and Tocks Island reservoirs in Area 15 and the Raystown and Gathright reservoirs in Areas 17 and 21, respectively.

Practical Surface Water Development

The determination of major river storage potential was based on information from other studies on sites which had been previously investigated. This included information from the NENYIAC Study of New York and New England, basin studies for the Connecticut, Delaware, Susquehanna, and Potomac Rivers, and various state studies. In each Area, a list of storage possibilities was made by screening all sites and selecting those that appeared to involve the highest degree of feasibility, assuming hypothetically, a firm need for the stored water. The determination of which storage projects to include in the

TABLE 25
MINIMUM STREAMFLOW
AND AVAILABLE
WATER RESOURCE
BY NAR AREAS

Area	Minimum Streamflow	Available Water Resource
	(million gallons per day)	
1	824	828
2	2,560	2,568
3	1,650	1,657
4	1,115	1,124
5	1,020	1,029
6	578	596
7	530	670
8	1,425	1,697
9	690	800
10	312	394
11	1,610	1,640
12	1,325	2,261
13	185	623
14	735	852
15 (1)	4,075	4,840
16	781	845
17 (2)	1,530	1,741
18	935	1,085
19	670	776
20	65	78
21 (3)	597	674
NAR	23,212	26,778

(1) Includes yield of Tocks Island and Beltzville Projects
(2) Includes yield of Lake Raystown
(3) Includes yield of Gathright Lake

potential category was a matter of judgment, based on the results of the previous studies and information received during the NAR Study.

The potential for beneficial storage other than flood control in upstream reservoirs was evaluated by the Department of Agriculture. This storage was derived from watershed inventories and is the maximum practical development based on yield, topography and rights of way. An estimate of the maximum storage that can practically be developed in each Area is given in Table 27.

Safe yield is the amount that can be drawn from a water source at a predicted level of risk. Safe yield from potential major river storage reservoirs was estimated using generalized yield-storage relationships. These yield storage relationships were developed for various portions of the NAR Region using computer analyses of existing and synthesized monthly flow records. The analyses take into consideration, in addition to the flow record and the amount of storage, the location -- at the site or at the outflow point of each basin -- at which yield is measured and the degree of certainty with which the yields can be expected. For most Areas gross yield was computed as the sum of the yields at the sites. For some Areas, where the needs for water occurred predominently down stream, yield-storage relationships at the outflow point were used. In either case risk levels equal to those used to establish present minimum flows were accepted.

TABLE 26
MAXIMUM PRACTICAL STORAGE DEVELOPMENT BY NAR AREAS

Area	Major Rivers	Upstream	Total
	(thousand acre-feet)		
1	3,435	301	3,736
2	1,300	631	1,931
3	630	606	1,236
4	720	622	1,342
5	210	880	1,090
6	267	702	969
7	600	768	1,368
8	1,378	1,219	2,597
9	113	220	333
10	439	212	651
11	635	480	1,115
12	1,972	1,604	3,576
13	-	-	-
14	219	276	495
15	951	1,000	1,951
16	40	87	127
17	2,723	1,723	4,446
18	-	267	267
19	1,019	776	1,795
20	686	734	1,420
21	992	1,445	2,437
NAR	18,329	14,553	32,882

The determination of yield from the potential upstream development was based on regional generalizations derived after hydrologic analysis of yield-storage relationships in upstream areas. A one percent chance of shortage was adopted as consistent with established criteria for this type of development. It was assumed that it would not be practical to operate potential upstream reservoirs for points located substantial distances downstream, and yields were determined at each site.

Gross yields from potential surface storage were reduced by the existing minimum flow to avoid duplication and a reduction was made for possible overlap in drainage area controlled by major river and upstream storage.

Table 27 shows the corrected total yield from surface water development and its upstream and major river components.

Practical Ground Water Development

The practical development yield of ground water was developed by the U. S. Geological Survey and the data represent conservative estimates of maximum withdrawal rates that could be sustained as determined by the hydrologic and geologic characteristics of the aquifers. Separate information is included for coastal plain strata, consolidated rocks and glacial deposits. Yields are further sub-divided according to prospective use, as indicated by the nature and location of the resource, into the higher yield wells for municipal and industrial waters and the smaller developments more suitable for rural and irrigation water. The latter consist mainly of wells in crystalline and metamorphic rocks generally yielding less than 100 gallons per minute (gpm).

TABLE 27
NET YIELD FROM MAXIMUM PRACTICAL SURFACE WATER DEVELOPMENT BY NAR AREAS

Area	Major River	Upstream	Total 1/
	(million gallons per day)		
1	2,530	252	2,757
2	2,440	531	2,823
3	400	495	859
4	877	465	1,139
5	385	946	1,282
6	452	712	1,095
7	1,440	820	1,984
8	1,875	1,217	2,922
9	79	213	290
10	562	222	755
11	922	348	1,250
12	3,883	1,830	4,974
13	-	-	-
14	325	280	550
15	1,295	948	2,094
16	85	117	199
17	3,879	2,045	5,537
18	-	222	222
19	1,441	508	1,864
20	913	568	1,359
21	831	1,001	1,702
NAR	24,614	13,740	35,657

1/ Total adjusted for drainage area overlap between major river and upstream development.

Table 28 is a summary of practical ground developments for the 21 Areas. It should be noted that these data are gross estimates without consideration of system effects, namely reduction in streamflow. Depending upon geologic and hydrologic conditions, pumping of ground water by wells in an Area may simply capture ground water outflow to the streams. Wells adjacent to streams may induce infiltration directly from the streams and wells more distant may interrupt water that would seep to the streams. The effect could be the same as taking water directly from the river.

Total Developable Resource

In order to integrate the resource available through additional ground and surface development into the total developable resource, several assumptions were made with regard to the complex relationship between surface and ground water.

Since the larger industries and cities are generally located on or near the larger streams, it was assumed that allowances should be made for subtractive effects on streamflow when incorporating municipal and industrial ground water. On the other hand, since most of the rural and irrigation ground water occurs at some distance from major streams and in consolidated rocks, it was assumed that the time lag would be such that no appreciable subtractive effects would occur during low flow periods.

TABLE 28
SUMMARY OF PRACTICAL GROUND WATER DEVELOPMENT IN NAR BY AREAS

Area	Rock Type or Geologic Formation	Municipal and Industrial	Rural and Irrigation
		(million gallons per day)	
1	Consolidated	230	325
	Glacial	620	-
2	Consolidated	-	393
	Glacial	640	-
3	Consolidated	-	277
	Glacial	520	-
4	Consolidated	-	160
	Glacial	410	-
5	Consolidated	-	271
	Glacial	60	-
6	Consolidated	-	183
	Glacial	480	-
7	Consolidated	-	240
	Glacial	325	-
8	Consolidated	275	463
	Glacial	1,010	-
9	Consolidated	-	558
	Glacial	380	200
10	Consolidated	113	219
	Glacial	320	-
11	Consolidated	492	493
	Glacial	225	-
12	Consolidated	316	561
	Glacial	840	-
13	Glacial and coastal plain	750	-
14	Consolidated	429	47
	Glacial	200	-
	Coastal plain deposits	24	-
15	Consolidated	684	386
	Glacial	500	-
	Coastal plain deposits	747	-
16	Coastal plain deposits	233	-
17	Consolidated	2,595	993
	Glacial	1,860	-
18	Consolidated	-	80
	Coastal plain deposits	793	7
19	Consolidated	1,597	514
	Coastal plain deposits	145	24
20	Consolidated	98	170
	Coastal plain deposits	81	28
21	Consolidated	757	369
	Coastal plain deposits	49	21

Dashes signify negligible quantities

The subtractive effects of developing municipal and industrial ground water were accounted for by use of generalized factors expressing the percentage of the total water estimated to be additive to the over-all resource. For the glacial deposits, which occur mostly in close proximity of streams, and have high permeability and good hydraulic connection, it was assumed that only about 5 percent of the pumped water would represent water from storage rather than the stream, and thus be additive. Wells in the consolidated rocks would be more widely distributed rather than concentrated near large rivers and streams and would draw on storage to a greater extent during low flow months. The additive portion of pumped water was assumed to be 20 per cent in this case. For coastal plain formations, practically all (95 percent) of the development was considered additive in the case of artesian aquifers while in the shallow surficial deposits, none of the yield was assumed to be additive to the over-all resource.

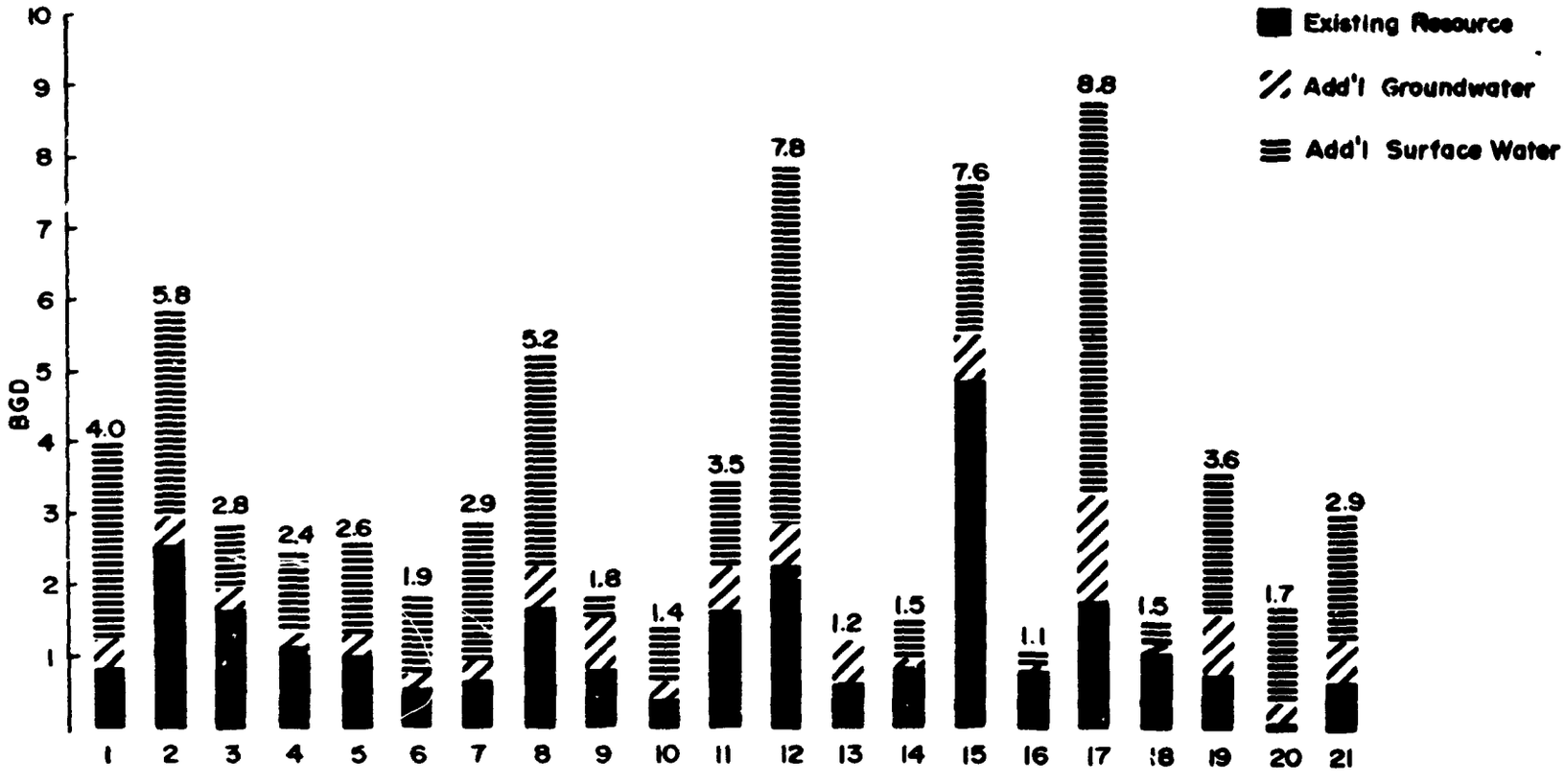
Table 29 and Figure 21 contain the net increments of ground water and surface water that are combined with the now available resource to derive the practical development limit for each Area. In addition to the reduction due to subtractive effects of ground water development, an allowance was made for estimated existing ground water use to avoid any duplication in the development values.

Figure 22 is a chart comparing existing development and maximum practical development in each Area in percent of average runoff.

TABLE 29
SUMMARY OF TOTAL DEVELOPABLE WATER RESOURCE IN NAR BY AREAS

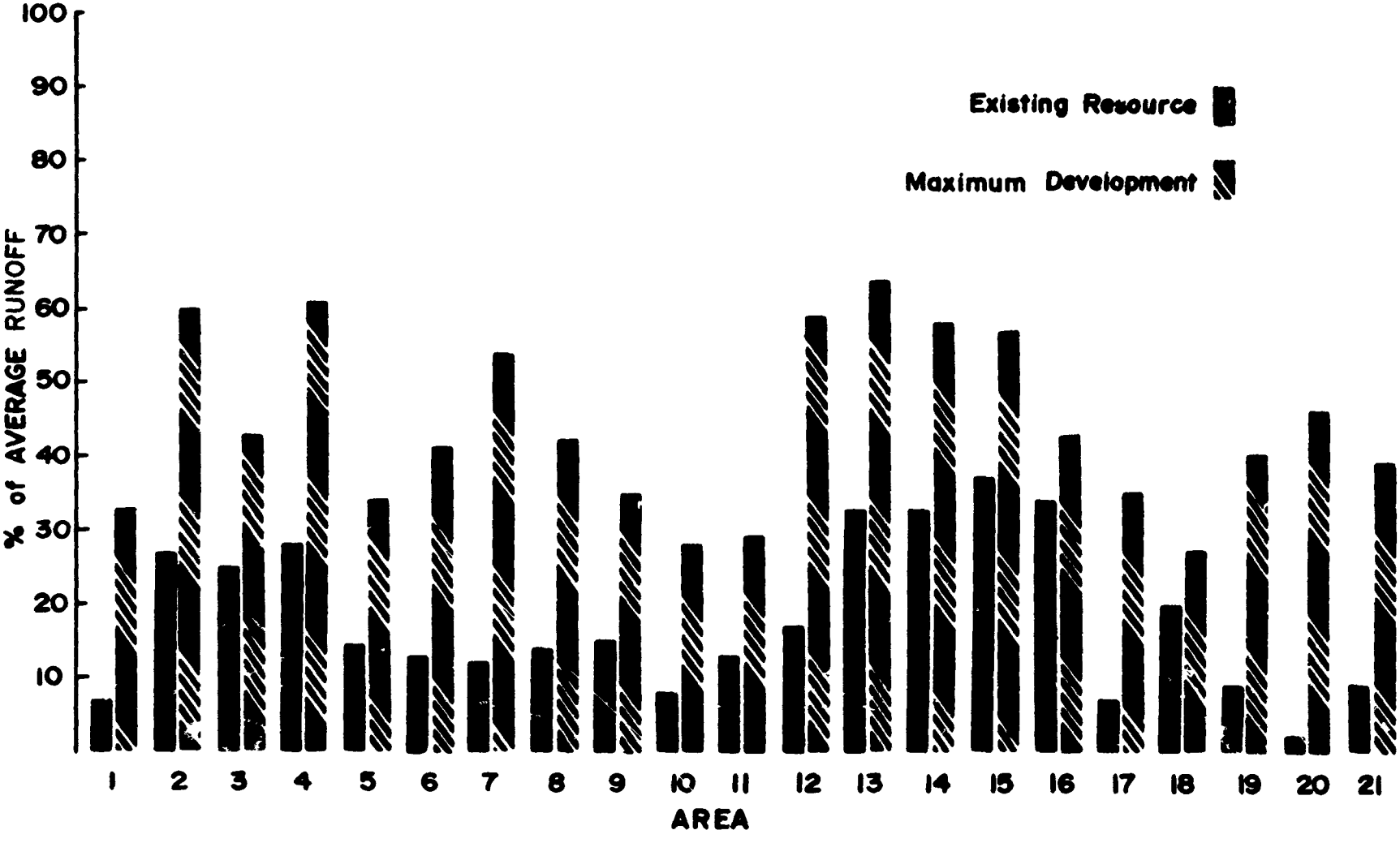
Area	Presently Available	Additional Yield		Total Practical Development
		Surface Storage	Ground Water	
	(million gallons per day)			
1	828	2,757	395	3,980
2	2,568	2,823	423	5,814
3	1,657	859	300	2,816
4	1,124	1,139	179	2,442
5	1,029	1,282	271	2,582
6	596	1,095	198	1,889
7	670	1,984	240	2,894
8	1,697	2,922	540	5,159
9	800	290	742	1,832
10	394	755	224	1,373
11	1,640	1,250	583	3,473
12	2,261	4,974	603	7,838
13	623	-	589	1,212
14	852	550	94	1,496
15	4,840 (1)	2,094	628	7,562
16	845	199	21	1,065
17	1,741 (2)	5,537	1,478	8,756
18	1,085	222	161	1,468
19	776	1,864	912	3,552
20	78	1,359	265	1,702
21	674 (3)	1,702	562	2,938
NAR	26,778	35,675	9,408	71,843

(1) Includes yield of Tocks Island and Beltsville projects.
(2) Includes yield of Lake Raystown.
(3) Includes yield of Gathright Lake.



NAR
TOTAL PRACTICAL DEVELOPMENT
Ground and Surface Water
(billion gallons per day)

Figure 21



EXISTING AND DEVELOPABLE WATER RESOURCES
as Percent of Average NAR Runoff

Figure 22

LAND

Related land resources have been defined in this Study as those lands and land-based resources -- (such as plants, animals, housing, transportation and scenery) -- that are affected by or affect (that interact with) the development and management of water resources, needs and devices. The remainder of this Chapter deals with land in the Region on a very broad basis to consider the interactions between land and water resources. Land uses in the NAR are reviewed to determine which problems will be most significant and how these problems might be handled.

Land Uses

The NAR covers a total area of 110,456,000 acres, of which 4,720,000 acres are water. Urban, agricultural, and forest activities are the principal contenders for land resources within the NAR. Present land use is about 15 percent crop land, 6 percent pasture, 66 percent forest, 6 percent other and 6 percent urban land as shown in Table 30.

Eighty percent of the Region's approximately 50 million people live on 6 percent of the Region's land area known as megalopolis. The rapidly expanding population and associated land requirements compete with agriculture for the more productive land.

The trend to more urban and less rural population is expected to continue in the Region. The farm portion of rural population is expected to decline significantly. In 1960, nearly 81 percent of the population was urban. It is evident that these population pressures with the present Regional population density of approximately 264 persons per square mile, will continue to have a significant impact on land use. With this competition for land resources becoming intense, planning for the use of these resources to meet human needs and desires is assuming greater importance. New demands for environmental quality and for variety in life also add to these pressures on land use.

For agriculture and forestry, land represents a factor of production. Soil type and quality, in association with other physical properties, directly influence the parameters governing crop yield and farm output. In the creation of urban space, however, land is significant primarily as a site upon which more or less space is "produced" depending upon the type of structures that are erected and their pattern of distribution over the landscape.

Urban Land Problems

There is no evidence of a scarcity of land for urban growth within the NAR as a whole. Despite wide variations in landform and topography, physical features offer few serious constraints to urban development. However, the prospect of 40 million additional people in the NAR between 1960 and 2020, simply as an extension of the present pattern of settlement, may be expected to increase exponentially the many problems now confronting the Region's cities and metropolitan areas.

Transportation problems in the NAR seem to stem from the dispersed and underorganized development of land combined with the over-use of private transportation and lack of support of public transportation systems. The current pattern of suburbanization and reliance on the automobile results simultaneously in maximum congestion and maximum dispersion. The results are loss of potential large-scale open spaces, lengthened commuting trips, and growing severity of air pollution over wider areas.

TABLE 30
NAR LAND USE BY AREAS, 1963

Area	Crop-land	Past-ure	Forest	Other Land	Urban	Water	Total
			(thousand acres)				
1	240	25	4,240	31	35	139	4,710
2	196	41	4,659	66	94	400	5,456
3	287	70	3,099	23	96	182	3,757
4	132	26	1,833	36	86	95	2,208
5	215	15	2,974	135	126	523	3,988
6	170	34	1,970	155	142	221	2,692
7	168	57	2,390	188	273	156	3,232
8	598	341	5,489	272	258	170	7,128
9	145	59	1,616	280	518	310	2,928
10	237	159	1,922	245	249	104	2,916
11	1,222	920	4,427	439	132	476	7,616
12	1,296	704	5,202	701	390	261	8,554
13	63	4	361	77	548	164	1,217
14	229	45	588	162	448	48	1,520
15	1,811	459	4,048	848	799	204	8,169
16	212	21	760	212	204	123	1,532
17	4,019	1,474	9,779	1,252	883	200	17,607
18	1,766	209	1,740	707	228	563	5,213
19	1,823	1,148	5,289	624	373	132	9,389
20	582	359	2,441	238	116	104	3,840
21	636	532	4,916	209	346	145	6,784

The environmental crisis seems significantly related to the dispersed and underorganized pattern of land development in the NAR. Land development presently occurs within a largely unregulated system of private ownership and physical disarray, both functionally and visually, is almost inevitable. Affluence, which contributed to the disarray, permits escape from the most affected areas and leads, in turn, to the further degradation of new areas.

The social crisis facing the Region's urban areas is less easily defined but no less real. Typical of this problem is the anonymity felt by the individual within the metropolitan setting in which short "contacts" with people replace longer "associations" and a sense of community. With the lack of a social focus simultaneously occurring in the physical and institutional pattern of the metropolis, individual identification either with a "place" in the city or with the traditions of local institutions progressively weakens.

These urban problems lead to an acceleration of the problems of central cities. There is a loss of civic form that seems to result from both dispersion and deterioration and leaves almost every municipality with a weak center and a functionally irrelevant administrative boundary. While municipal jurisdiction is local, municipal problems are increasingly regional in scope. The absence of relationship between the physical urban pattern and the pattern of municipal or community institutions not only renders some problems insoluble, but makes the more penetrating questions difficult even to sort out and define.

These critical problems cannot be ignored in long-range land and water resources planning for the NAR. They pose what are perhaps the greatest challenges for and development and planning in the coming decades -- the mobilization of all Regional resources to help create a more humane urban environment.

Urban Development Alternatives

In evaluating the range of future alternatives for urban growth (see Appendix G), five general criteria were used: urbanity, open space, efficiency, community, and choice.

Urbanity and open space are regarded as the two most critical physical values. They are two poles of urban life. Both can be attained when urban development is clustered or concentrated. Even moderate clustering rapidly expands the availability of large open spaces without substantial additional acreage being required. Urbanity flourishes when intense and varied human interests and services are close at hand. Opportunities for extending the benefits of urban growth arise with high net densities affording urbanity, and relatively low gross densities affording open space.

Efficiency in urban form depends upon minimizing the use of land and transportation.

The sense of community is maximized under conditions of effective local government, where there is opportunity for association among families and individuals, in an environment in which urban obsolescence can be controlled.

The objective of choice is attained where the individual and family is offered opportunity for an array of life styles, and range of available transportation modes, as well as choice in tenure between renting and purchasing housing.

These five criteria were broken down into 26 sub-criteria and applied to five possible patterns of urban development: Uncontained Sprawl, Contained Sprawl, Clustered Planned Unit Development, Super Buildings in combination with Planned Unit Development, and Central City Super Building Development.

Weighted values for applying these criteria were derived based on the extent to which the alternative urban development patterns satisfied the 26 sub-criteria. These weighted values were then assigned to the 3 NAR objectives of National Income. (NI), Regional Development (RD), and Environmental Quality (EQ), defined in Chapter 6, pages 122-123.

The total scores attained by the alternative urban development patterns are shown in Table 31.

The most striking fact revealed by the comparative analysis is that neither population size nor gross population density is shown to be the critical element affecting open space, efficency or the quality of life. What appears far more significant is the pattern of development. Those patterns that result in high net population densities yield significantly higher savings in land, increased efficiency, greater range of choice and greater mobility. High concentrations through the super building or megastructure concept and clustering through the planned unit development pattern permits a radical saving of large and varied open spaces. Such land conservation could be achieved in central city redevelopment, peripheral, satellite and new "town" development, particularly if site locations are planned in relation to intersecting transportation lines or modes.

TABLE 31
MULTIPLE OBJECTIVE EVALUATION OF ALTERNATIVE URBAN PATTERNS, NAR

	Alternatives	NI	RD	EQ	Total
I	Uncontained Sprawl	9	1	-1	9
II	Contained Sprawl	18	3	-1	18
III	Clustered Planned Unit Development	18	29	7	54
IV	Super Buildings with PUD's	26	40	8	74
V	Central City Super Buildings	26	38	9	73

Of the five alternatives that were considered, super buildings or megastructures, in combination with planned unit development, seem to offer the maximum advantages in planning of future urban growth within the NAR. These forms of development would be applicable to central city rebuilding as well as accommodating new urban growth in the as yet undeveloped portions of the NAR.

The urban geometry of high net densities simultaneously creates the conditions for the two most important physical values of the city: (a) urbanity: the intensity and variety of services, associations and interests close at hand, and (b) open space: woods, lakes and specialized agriculture at a scale of openness that permits an entirely different environment readily accessible to the residential setting.

With a doubling of population within the NAR, only major innovations in both the development design and the development process can secure and enlarge upon the more traditional values of ownership, privacy and mobility. The concentration of both open space and building space seem to be complementary for quality urban development. Given a projected increase of 40 million people, most of whom will live within the Region's existing metropolitan belt, some constraints on ad hoc decision-making as it affects major changes in land use seems inevitable. Such constraints will apply equally to public agencies and private developers.

In the future, given the enormous land resources of the NAR, the question of how, rather than how much, land is used for urban purposes may be by far the most important issue in metropolitan planning and development.

Rural and Forest Land Problems

The analysis of rural and forest land use clearly indicates an abundance of land is physically available in relation to the total demands placed upon the land resource base. It would be possible to meet the projected requirements for food and fiber in the Region. There may be a deficiency after the year 2000 to meet specified needs, resulting in shifts of production to the poorer lands and subsequently greater production costs. There is, however, a distributional problem. In addition, institutional constraints and rigidities and powerful social restraints result in much of the land resource base to be unavailable for general or specific use.

Land requirements for agriculture are expected to decline. Each acre will be called on to do more, however, so that it will need to be better protected and managed.

The comparisons in Table 32 consider land needs for food and fiber production, urban and other requirements as single uses only. When consideration is given to multiple use of the land resource, then land management must include provision for more than the traditional functions of efficient food production. Open fields will be needed to provide a visually pleasing landscape, wildlife refuge, habitat for hunters game, open space and recreational opportunities. Land management is needed for aiding in the preservation of social cultures, historical sites and unique areas. Future land use must provide these multi-purposes.

Rural and Forest Development Alternatives

Meeting the planning objective of efficiency of production (National Income) could be accomplished, given necessary shifts in production patterns. Institutional rigidities rather than production capability are the major constraints. Analysis reveals current production patterns are approximately 36 percent less efficient than if land resources were freely mobile. Inflexible zoning, land taxing practices and speculation as well as personal preferences and life styles keeps land from being put to its most efficient productive use. Since land is not a mobile resource, planned land use change and/or improved management are the only practical means of relating availability to demand in an efficient or desirable manner. Projections give indication of the location and magnitude of the demands in the future. Planning provides the vehicle to achieve greater benefits from the resource base.

TABLE 32
PATTERNS OF LAND USE CONSISTENT WITH
PROJECTED DISTRIBUTION OF AGRICULTURAL PRODUCTION
IN NAR, 1980-2020

	Cropland	Pasture	Forest	Urban and Other	Remaining Land Available1/
	(million acres)				
1980					
Historical Trend	12.1	5.7	72.3	15.6	
Visual Quality	11.8	8.9	56.7	18.7	9.7
Efficiency2/	11.2	8.1	42.1	18.7	25.6
2000					
Historical Trend	8.7	4.0	73.0	20.0	
Efficiency	11.5	9.0	45.9	18.7	20.6
2020					
Historical Trend	6.3	2.7	70.8	25.8	
Urban and Other Development 3/	12.6	9.8	43.8	30.4	9.0

1/ Not required to meet projected production needs
2/ economic efficiency, i.e., planning land use to provide food and fiber at a relatively low cost.
3/ The amount of additional land needed for urban and other development

Meeting the Environmental Quality objective presents different problems. Should the historical trend in the production of food and fiber continue, the current desirable contrast of cropland, pasture, forest, town and city will probably disappear before the target date 2000. Land use shifts of this magnitude will appreciably reduce the visual quality of the Region. Analysis reveals production and visual quality maintenance is obtainable on essentially the same number of acres but through a better distribution of land use with approximately a 69 percent increase in production costs. Again, the objective is obtainable given society's desire to pay the difference and initiate action to plan and manage the resources.

Meeting the Regional Development objective presented an opportunity to evaluate urban and other development if zoning were utilized to maintain agricultural production on the better suited lands, reserving urban and other development to the lower or poorer land classes and an alternate evaluation of continued development in the historic patterns. In either case, land is available; however, agricultural production costs are increased considerably if current urban and other development trends continue. Once again, the objective is obtainable with a known cost to society, given its choice in future urban and other development patterns.

Although vast areas of sparsely populated forested and agricultural lands exist in the Region, the dominant influence on land use emanates from the metropolitan areas which desire to share in the use of these lands for such purposes as recreation, transportation, mineral and water production in addition to normal food and fiber production, in order to enhance the over-all quality of society. Therefore, location of a variety of land use within a day's drive of a major metropolitan area increases both quality and alternatives available to the users. However, this does change the course of planning since isolation of land uses such as agricultural, forested, recreational, urban, or other specific uses in separate areas of the Region, even though proven most efficient from a production viewpoint, would be an unacceptable alternative due to the great loss in readily available contrast and quality of the environment. Fortunately, much of this problem is circumvented by the natural geographic distribution of different kinds of qualities of land, water and mineral resources throughout the Region. Nevertheless, it still remains to determine alternatives approximating the most efficient and yet acceptable mix of land use considering both land capability and demands placed upon the land resource base in order to develop land use and management policies and programs to more fully develop the land resource.

The combined efforts of long-range planning and control regulations by the responsible units of government are essential if man is to control his natural environment. Quality of the environment with emphasis on open space and recreational amenities will contribute greatly to the life styles of future living in the NAR.

CHAPTER 5

THE PROCESS OF PROGRAM FORMULATION

Plan formulation is the key phase in planning. When this process is understood comprehension of the plan will be greater and subsequent planning efforts can more easily reproduce, update and improve the process.

Much of the material in this chapter is drawn from Appendix T, "Plan Formulation," in which the plan formulation process used in this Study is presented in detail.

Plan formulation is divided into two basic components for presentation in this Chapter: first, the methods used for generation of data for alternative planning elements at the framework level, and, second, the methods used to select programs from among the alternatives. These two parts of plan formulation tend to occur more or less simultaneously, but the breakdown is useful for exposition.

The methods described in this chapter reflect the theory of multiple objective planning; certain traditional engineering, hydrologic, and economic methods of water resources planning; computer modelling techniques; and techniques for communication in planning. The salient features of these methods are described as they were used in the NAR Study and samples are shown of the type of information available to planners at each step of the plan formulation process.

GENERATION OF ALTERNATIVES

Basic Assumptions

Once the boundaries of the NAR were established, two types of assumptions had to be made so that the available data could be used for projections of the alternative planning elements: needs, devices, benefits and costs. The assumptions are described for each planning element in the next two Chapters while a description is given here of the procedures by which these assumptions and projections were developed and used.

The first set of assumptions concerned the likely growth rates for personal income, earnings, employment and population under the three different objectives. Other assumptions, more closely related to the individual needs, were also a part of this first set and concerned: industrial productivity, power consumption, crop production, cargo movement, recreation days, fishing and hunting days, pollution levels, flood damages, rates of drainage and erosion, levels of diseases and amounts of landscapes.

The second set of assumptions concerned the quantities of water and associated resources that would be used for fulfilling each need at the three assumed rates of growth of the above-mentioned activities. This second set of assumptions, also related to the three objectives, included items such as: the rates of use of different types of water by the various industries in the Region; the amounts of surface water required by recreationists; and the quantities of waste treatment required to meet water quality standards.

Certainly the assumptions about population growth rates are the most basic to all of the projections of the Study but just as important in the final decisions for a plan are the second level assumptions that primarily concern available technology and peoples' desires. Changes in either of these factors may be so volatile and unpredictable that either one can drastically reduce or increase the use of water and related land resources for any of the needs.

Stages of Plan Formulation

While the process of gathering data, making assumptions and projecting the planning elements seems to be straight forward, it was carried out during the NAR Study by increments in a repetitive manner. This process was spread throughout the three plan formulation stages described in Chapter 1. Each of these plan formulation stages consisted of meetings between the cooperating states and agencies and lasted for several months. During each stage there was an increase in data refinement, completeness and degree of accuracy.

There were three stages or rounds of the plan formulation process and the first ran from September 1968 through June 1969. The Plan Formulation Work Group produced two successive sets of data during the first stage. The first set of data was a general attempt to bring together available data and to make preliminary assumptions and projections. Much of this material was in words rather than numbers. A sample work sheet used for the first set of data is shown in Figure 23.

The second set of data was more complete and formally arranged. This set was accompanied by descriptions of the assumptions underlying each need and by summaries of the implications that each alternative plan would have for each Area. A sample work sheet for the second set of data is shown in Figure 24.

The second stage of plan formulation ran from June 1969 to September 1970 and data and projections were formally reviewed during this time by the Coordinating Committee. A new, third, set of data was derived from this review process and was displayed on work sheets such as the sample shown in Figure 25. This data was even more complete and was arranged for easy use in deriving a mixed objective program.

Members of the NAR Board of Consultants listening to a presentation at the ninth meeting of the Coordinating Committee at Burlington, Vermont, 17-19 June 1969. (Study Group, North Atlantic Regional Water Resources Study).

Basin D-14

Year 1980

Emphasized Objective NE

Demand Unit (in thousands)

Quantities Available		BIG-GAME MAN-DAYS	BIG-GAME $ VALUE	SMALL GAME MAN-DAYS	SMALL GAME $ VALUE	WATERFOWL MAN-DAYS	WATERFOWL $ VALUE
	DEMAND	371	1,484	1,150	2,121	88	352
	CAPABILITY	207	836	1,168	2,155	51	204
Physical Balance (single purpose)	NEED	164		0		37	

Recommended Device (single purpose)

BIG GAME

Emphasized Objective

Total Benefits

The following devices should have been completed under present level of big game needs are to be satisfied

1 access and legislation. The legislation should allow maximum sustained yield.

Total Costs

2 Maintain habitat at present level

Net Benefits

Objective ( )

Total Benefits

If above devices were completed the big game resources would support 584,000 man-days of use by 1990 to satisfy demand for 1980 level

Total Costs

next year.

Net Benefits

SMALL GAME

Objective ( )

Total Benefits

Over all time are use of small game needs for 1980, last of small game needs are to be satisfied in future beyond next year the following devices must be implemented at least by 1980.

Total Costs

1 access and legislation. The legislation should allow maximum sustained yield.

Net Benefits

2 Maintain habitat at least at present level.

Comments and continuations:

WATERFOWL

The following devices should have been implemented under present level of waterfowl needs are to be satisfied

1. access
2 Legislation (see appropriate unit plan)
3 Maintain habitat at present level

3 of these devices were implemented on present level for the waterfowl resource will support 136,000 man days of hunting

EXAMPLE OF WORKSHEET FOR FIRST SET OF PLAN FORMULATION DATA

Figure 23

HAR Area 14 - Summary Table 1

	1980	2000	2020
1. Municipal and Industrial Water Supply			
	Demand 780 mgd, 270 mgd increment over present. Suggested devices: 53 mgd wells and river intakes. First cost: Surface water $0.0 Ground water $5.0 million Total $5.0 million	Demand 1090 mgd, 310 mgd increment over year 1980. Suggested devices: 53,400 AF storage in 5 reservoirs (111 mgd), 45 mgd wells; 111 mgd treatment plants (4 plants); river intakes. First cost: Surface water $129.0 million Ground water $ 4.0 million Total $133.0 million.	Demand 1490 mgd, 400 mgd increment over year 2000. Suggested devices: 80,000 AF storage in 2 reservoirs (135 mgd); 300 mgd diversion from other basins; 135 mgd treatment plants (2 plants); river intakes. First cost: Surface water: $311.0 million Ground water: 0.0 Total $311.0 million
2. & 5. Self-Supplied Industrial Process and Cooling Water	Demand 730 mgd, 210 mgd increment over present. Suggested devices. Demand can be accommodated by presently available surface supply with intake structures and pumping facilities, at no cost for water supply.	Demand 1060 mgd, 330 mgd over year 1980 Suggested devices: Same as for 1980.	Demand 1560 mgd, 500 mgd increment over year 2000. Suggested devices. Same as for 1980
3. Rural Domestic and Livestock Water Supply	Demand 14 mgd, 1 mgd over present. Suggested devices: 1 mgd wells. First cost: $0.1 million	Demand 17 mgd, 3 mgd over year 1980. Suggested devices: 3 mgd wells. First cost: $0.3 million	Demand 20 mgd, 3 mgd over year 2000. Suggested devices: 3 mgd wells. First cost: $0.3 million.
4. Irrigation Water Supply	Yearly demand 32,000 AF, 22,000 AF increment over present. Suggested devices: 9,000 AF storage and 13,000 AF wells and streams. First Cost: $5.7 million Annual cost: $0.8 million	Yearly demand 41,000 AF, 11,000 increment over year 1980. Suggested devices: 5,500 AF storage and 5,500 AF wells and streams First cost: $8.7 million Annual cost: $1.0 million	Yearly demand 53,000 AF, 14,000 increment over year 2000. Suggested devices: 8,400 AF storage and 5,600 AF wells and streams. First cost: $10.4 million Annual cost: $ 1.1 million

EXAMPLE OF WORKSHEET FOR SECOND SET OF PLAN FORMULATION DATA

Figure 24

VISUAL AND CULTURAL ENVIRONMENT - DEMAND

POSSIBLE DEVICES

Area 14

OBJECTIVE	BENCH MARK YEAR	Unique Natural Landscape	Unique Cultural Landscape	Historic Sites	Develop Historic	Develop Historic Sq. Mi.	Clean Water	Percent of Area Metropolitan Complex (Akron-Suburbs)	Percent of Area	Legal - Fee Simple Purchase (F.S.)	Legal - Easements (E.A.E.)	Legal - Deed Restrictions	Legal - Zoning	Legal - Tax Incentive-Subsidy (T.I.)	Impoundment	Water Supply Instal.	Waste Treatment	Recreation Facilities	Wildlife Facilities	Preventive	Corrective	Sh. Protection Enforcement	Flood Plain Management	Watershed Management	Millions $ COST
	Pres		9																						
EQ	1980		9		130	30			100%																
	2000				130	30																			
	2020				130	30																			
NE	1980		9		65	15			100%																
	2000				65	15																			
	2020				65	15																			
RD	1980		9		130	30			100%																
	2000				130	30																			
	2020				130	30																			

* Cost is given in 1970 values of land.

EXAMPLE OF WORKSHEET FOR THIRD SET OF PLAN FORMULATION DATA

Figure 25

NON-MONETARY BENEFITS AND COSTS

AREA 14
OBJECTIVE All
NEED S-Power Cooling

DEVICES	NEEDS	INTERACTIONS	BENEFITS EQ	BENEFITS NE	BENEFITS RD	EXC S-A	NEEDS	INTERACTIONS	COSTS			EXC S-A
Wells Diversions Cooling Towers	1. Municipal and Industrial:	Complementary use	O	O	O		1. Municipal and Industrial:	Higher water temperature could cause taste and odor problem	L	L	L	
	2. Industrial Process and Cooling:	Complementary use	M	M	M			Competitive use	O	M	O	
	3. Rural Water Supply:		O	O	O		2. Industrial Process and Cooling:	Taste and Odor	O	O	O	
	4. Irrigation:	High temperature water aids growth of some crops	O	O	O		3. Rural Water Supply:	Competitive use of groundwater	O	O	O	
	6. Hydroelectric:	Complementary use	O	O	O			Higher temperature of return water	O	O	O	
	7. Navigation:	Complementary use	O	O	O		4. Irrigation:	Competitive use of water	O	O	O	
	8. Recreation:	More boating days if thermal pollution keeps streams from freezing	L	L	L		7. Navigation:	Competitive water use	O	O	O	
	9. Fish and Wildlife:	Possible improvement in crustacean and shellfish breeding in coastal areas	O	O	O		8. Recreation:	Competitive site use	O	O	O	
		Increased use of area by resting waterfowl if kept from freezing	L	O	O		9. Fish and Wildlife:	Thermal pollution disrupts natural habitat	L	M	L	
	10. Solid Waste Disposal:		O	O	O			Harmful to marine organisms taken up into intakes	O	L	O	
	11. Liquid Waste Discharge:	Higher water temperature increases assimilative capacity of stream	L	L	L			Reduction of aquatic life by mortality through condensers	O	L	O	
	12. Flood Control:		O	O	O		10. Solid Waste Disposal:		O	O	O	
	13. Drainage Control:	Withdrawal of groundwater lowers water table	O	O	O		11. Liquid Waste Discharge:	Water loss to stream	O	O	O	
	14. Erosion Control:		O	O	O			Lowered D.O. levels resulting in increased sulfides and acidity	O	O	O	
	15. Health:	Warm water decreases sedimentary capacity of streams	O	O	O		12. Flood Control:		O	O	O	
							13. Drainage Control:		O	O	O	
							14. Erosion Control:		O	O	O	
							15. Health:	Fish kills	O	O	O	

Abbreviations

EXC. S-A = Except Sub-Areas
H = high
M = medium
L = low
O = zero or insig.

EXAMPLE OF WORKSHEET ON DEVICE INTERACTIONS FOR THIRD SET OF PLAN FORMULATION DATA

Figure 26

There was some new information that accompanied this third set of data. A general description of each Area -- social, physical, economic and environmental characteristics -- was included along with information on the beneficial and detrimental effects of the use of various devices. This last information was an attempt to bring the consideration of non-monetary benefits and costs into the final planning decisions. Special forms were prepared for this information on device interactions as shown in Figure 26.

Many of the likely interactions between devices were described on these forms and were categorized as possibly beneficial, detrimental, or both. Examples of these interactions (shown in Figure 26) are navigation competing for water with power plant cooling and power plant cooling effluents decreasing or increasing the assimilative capacity of streams. The results of each interaction were considered for each of the 21 Areas as if the devices associated with the interaction were to be used to meet the Area's needs. Each interaction was assigned a high, medium or low benefit or cost if it was likely to occur in the particular Area. This descriptive material served as a reference for choosing among the alternatives.

The third and last stage of plan formulation ran from September 1970 to May 1972. The third set of data was used at the beginning of the third stage of planning to make the first derivation of a mixed objective plan. Six meetings of the Plan Formulation Work Group were held during this time to make planning decisions. Each meeting was held in or near a state capital so that state agency personnel and the staffs of the state Coordinating Committee representatives could easily participate. Their knowledge of local conditions made the plan more realistic and accurate.

While participating agencies handcrafted most of the Study data, assumptions and projections, a special effort had been begun during the first stage of plan formulation to develop a unified computer model for water withdrawal needs. The first results of these computer models became available during the meetings to decide on a mixed objective plan. These first results included estimates of four types of withdrawals -- fresh water, brackish water, waste water and consumptive use -- for the five needs of publicly supplied water, industrial self-supplied water, rural water supply, irrigation water and power plant cooling water.

These demand model results were provided the Work Group members in the format shown in Figure 27 NAR and agency staffs wrote 21 Area Programs as the most detailed recommendations of the Study. The results of the Plan Formulation Work Group meetings served as the basis of these Area Programs which are presented in Annex 1 to this Report. The tables of these Area Programs were the fourth set of data in the Study.

The Area Programs were reviewed by the Coordinating Committee acting as an ad hoc task force on plan formulation.

SECTORAL WATER DEMAND (MSD) (RWR(41,50,6))
NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY
RUN = 1960 2NE

SECTOR	TOTAL USE	SUB-BASIN PASSAIC: FRESH WATER SELF SUPPLY	SUB-BASIN PASSAIC: FRESH WATER PUBLIC SUPPLY	SUB-BASIN PASSAIC: WASTE WATER	RIVER BASIN PSSC RAR: BRACKISH WATER	RIVER BASIN PSSC RAR: CONSUMPTIVE USE
IAGR1	3	3	0	0	0	3
IAGR2	46	46	0	0	0	46
AGRA 3	0	0	0	0	0	0
MINING	0	2	0	0	0	1
COAL MNG	0	0	0	0	0	0
PETR,GAS	1	0	0	0	0	0
STN CHEM	21	18	0	10	0	1
CONSRCTN	4	0	4	0	0	4
ORDNANCE	0	0	0	0	0	0
FOOD ETC	59	17	0	0	34	11
TOBACCO	1	1	0	0	0	0
FABRYARN	37	21	11	0	5	4
APPRLTEX	1	1	0	0	0	0
WOOD PRD	0	0	0	0	0	0
FURN FIX	0	0	0	0	0	0
PAPER DX	149	125	5	0	17	10
PRNTPUB	1	1	0	0	0	0
CHEMPLST	689	168	29	0	504	81
PETRLREF	366	19	1	0	356	8
RUBBER	26	19	4	0	12	1
LEATHRPR	2	0	0	0	2	0
GLASSCLY	19	7	1	0	11	5
PRIM MFG	165	26	12	0	128	18
METLPROD	13	9	4	0	0	1
MACHEQPT	31	22	9	0	0	3
ELECEQPT	21	15	7	0	0	2
TRANSEQT	12	9	4	0	0	1
PROFSUPP	8	6	3	0	0	1
MISC MFG	3	2	1	0	0	0
IPOW30	3161	0	0	0	3161	0
WHRTRADE	9	0	9	0	0	0
FIN I RE	2	0	2	0	0	0
BUS SERV	1	0	1	0	0	0
MEDEDSRV	4	0	4	0	0	0
FED GOVT	2	0	2	0	0	0
STLOCGVT	5	0	5	0	0	0
INAG37	48	33	14	0	0	48
OFFCSUPP	0	0	0	0	0	0
SCRAPGDS	0	0	0	0	0	0
DOMESTIC	534	534	0	0	0	27
RUR DOM	14	14	0	0	0	5
TOTAL	5464	1883	136	15	4232	279

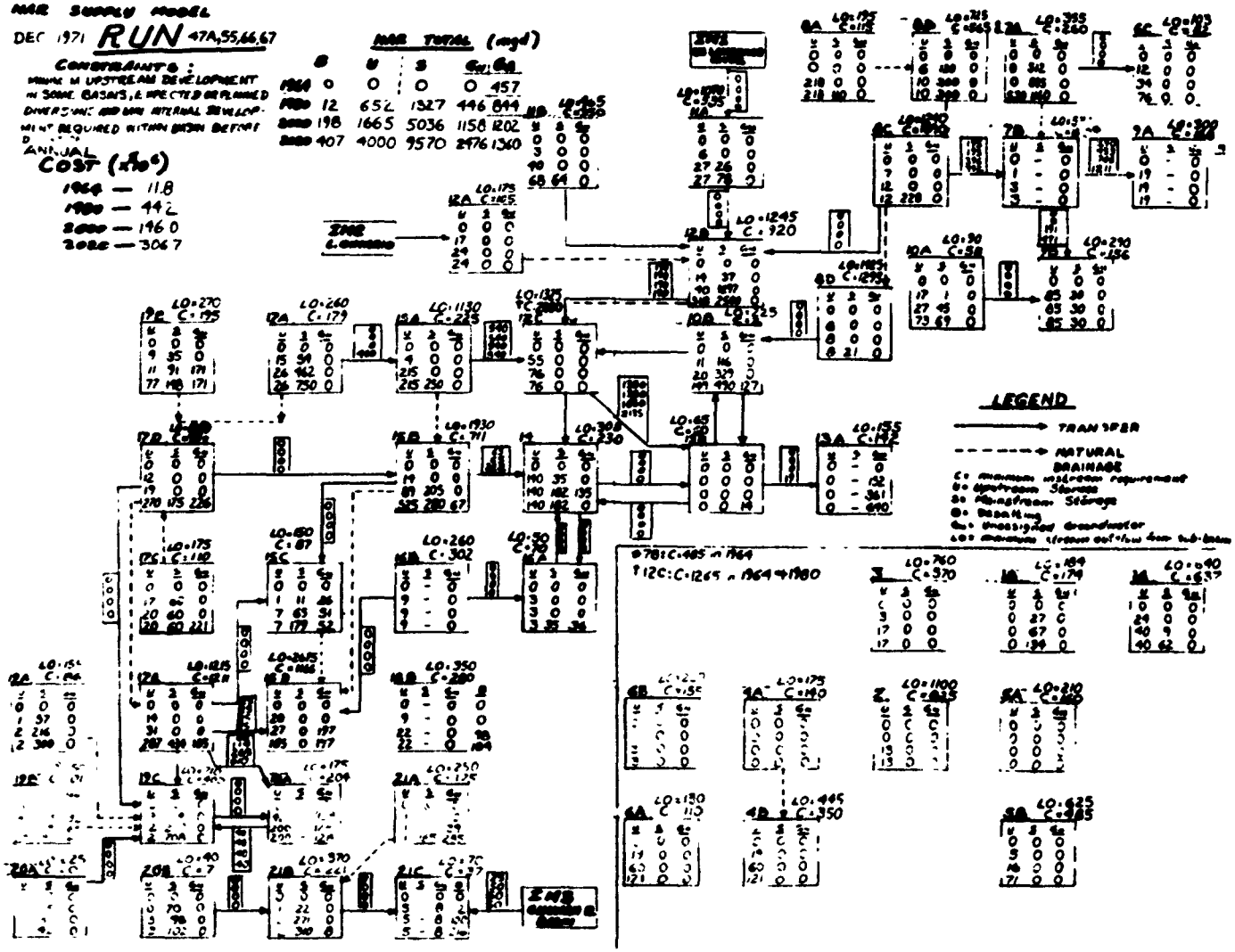
NET DEMAND (NSD) (NWDM(41,50,4))
NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY
RUN = 1980 2NE

SUB-BASIN PASSAIC	RIVER BASIN PSSC RAR: WATER USE CATEGORY 1	2	3	4	5	6	7	8	9
FRESH WATER	639	87	0	18	31	49	0	726	47
WASTE WATER	0	15	0	0	0	0	0	15	0
BRACKISH WTR	0	1070	0	0	0	0	3161	1070	0
CONSUMPTIVE	56	124	0	6	31	49	0	211	54

WATER USE CATEGORY	EXPLANATION
1	MUNICIPAL AND INDUSTRIAL (PUBLICLY SUPPLIED)
2	COMMERCIAL AND INDUSTRIAL (SELF SUPPLIED)
3	AGRICULTURAL SUPPLY (UNASSIGNED)
4	AGRICULTURAL SUPPLY (GROUND WATER)
5	IRRIGATION (UNASSIGNED)
6	IRRIGATION (GROUND WATER)
7	POWER COOLING
8	TOTAL UNASSIGNED WITHOUT COOLING
9	TOTAL ASSIGNED GROUND WATER

DEMAND MODEL RESULTS USED IN SECOND STAGE OF PLAN FORMULATION

Figure 27



SUPPLY MODEL RESULTS USED IN THIRD STAGE OF PLAN FORMULATION

Not the final results

Figure 28

The Plan Formulation Work Group met one more time when the results of a water allocation computer model were ready. This supply model information for water withdrawal needs was actually a part of the third set of data but because of its complexities and time in preparation it was not ready for use until this time. The supply model data was in the form of a chart shown in Figure 28 and was presented along with additional tables and explanations (shown in Chapter 7 of Appendix T). This supply model information was reviewed at this meeting and the final model runs were made afterwards. These final runs were made with the adjustments that the Work Group felt to be appropriate for the model assumptions and constraints. The Area Programs and the final data were adjusted by the NAR Staff after these last model runs.

The Regional Recommendations were also prepared at this time as the last part of the third planning stage. These Recommendations, which are the primary product of the Study, were derived from the Area Programs as a summary of Regional characteristics. The formulation of these Recommendations and the criteria on which they are based are described in the last section of this Chapter, "Making Study Recommendations"

SELECTION AMONG ALTERNATIVES

Area Programs

The process of selection among alternatives is part of plan formulation but is so important that it is reviewed separately. The selection process occurred during the second stage of plan formulation at the six, previously mentioned, meetings of the Plan Formulation Work Group. The procedures followed at these meetings were simple and centered around two activities: checking upon the soundness of alternative projections for each Area's needs, devices, benefits and costs and then selecting among these alternative planning elements. The first activity consisted of the Work Group reviewing the data, need by need and device by device, as it appeared on work sheets such as that of Figure 25. Questions by state representatives regarding data and assumptions behind the projections were explained primarily by personnel from the Federal agencies. Most questions were resolved at the meetings while some required further research or negotiation.

Examples of questions that arose at this time included concerns over the projected levels of recreation needs, i.e., visitor days; the level of present demand of specific industries for self-supplied water; and the likelihood of the responsible agencies permitting the suggested drainage control needs to be fulfilled for forest lands in some Areas. These discussions were greatly facilitated by the work sheets with the handcrafted data (Figure 25) and with the results of the computer demand model (Figure 27). The computer work sheets, for example, with breakdowns of water withdrawal needs by separate industries repeatedly aided in this data evaluation process by allowing state personnel to verify that every industry with which they were familiar was included.

As the checking activity was completed for an Area, the more difficult task of choosing among the alternatives was taken up for that Area. It turned out, however, that the first checking process greatly facilitated the making of choices among alternatives. The participants by this time had become very familiar with the alternative projections and with the assumptions behind these alternatives.

Choosing among the alternatives was a more deliberate activity than the review process. The choices for each Area included reaching agreement on:

1. a mixed objective for the Area
2. the level of each need required to attain the Area's mixed objective
3. the level of each type of device required to fulfill the needs
4. reviewing the original choice of the Area's mixed objective
5. the alternative needs and devices for alternative mixed objectives

The criteria for choosing among alternatives included:

1. the desires of the people who live in each Area as understood and expressed by the state participants;

2. the resources available in each Area;

3. the present type and level of resources used in the Area; and

4. the information available on the benefits and costs of the various alternatives.

This sequence of events leading to agreement for the mixed objective Area Programs was essential. Once the possible alternative planning elements were agreed to, no further choices could be made until the over-all mixed objective was agreed to for the particular Area. This objective mix served as the goal that was to be achieved in the Area when the needs were filled by certain types of devices. That is, agreements on the alternative levels of each need had to be guided by knowing what job was to be carried out by the commitment of resources to meet these needs -- what objectives were to be achieved. The agreements on devices could then be made in light of the needs they had to fulfill and the mixed objective to be achieved.

The mixed objective for an Area was established, such as an Environmental Quality emphasis with some Regional Development, and the intentions of these statements were defined and recorded and are given for each Area in Annex 1, Area Programs. In the above objective mix, for instance, Environmental Quality might be emphasized to preserve the Area's outdoor resources while allowing recreation activities to increase. Regional Development might be given some emphasis because of the Area's low per capita income. No objective is entirely eliminated in any Area even if it is not mentioned in the definition.

The levels of each of the fifteen needs were agreed upon at the meetings, if at all possible. When inaccuracies were found or disagreements occurred over assumptions the Work Group agreement provided only for the general level the need should have with the exact level established later by the NAR or agency staffs. This same approach was used to obtain agreement on devices.

While agreeing upon Area Programs the levels of needs and the quantities and types of devices chosen for a specific Area did not have to follow the mixed objective for that Area. For example, the Regional Development alternatives for needs and devices were not necessarily found to be the best choice to achieve a mixed objective emphasizing Regional Development in a particular Area. Environmental Quality levels for some of the needs and devices -- say visual and cultural and water recreation -- might actually achieve the desired Regional Development objective more effectively. These other levels, for instance, might attract the type of tourists who are willing to pay more for their experiences (and thus, help achieve the Regional Development objective) if it is accompanied by better scenery and less crowded recreation facilities.

The original agreement for each Area's mixed objective was reviewed after the agreements were reached on needs and devices. It was discovered in several cases that even though an agreement had been reached on what objective to emphasize for an Area not just some but most of the needs and devices agreed upon had a different objective emphasis. In these cases, the original objective mix was reconsidered to be sure it was the desired mix. In a few of these cases, changes were made in the objective mixes.

The final agreement concerned needs and devices for the alternative programs for each Area. This agreement concerned the major differences that were obvious to the Work Group at the time and served as the starting place and general guide for the NAR Staff when they drew up alternative Area Programs at a later time.

Regional Program

The Regional Program, presented in Chapter 8, is a description of Area mixed objectives; inter-basin transfers; and results of comparisons among needs, devices, benefits and costs.

The mixed objectives of the Regional description are taken directly from the Area Programs.

Transfers are needs that occur in one Area and are fulfilled by resources in or from another Area. The water transfers are taken from the computer supply model results.

Other transfers occur in the location or fulfillment of power plant cooling, water recreation, fish and wildlife and navigation needs. Water transfers are shown in Chapter 8 but the other transfers are an integral part of the Area Programs and could not be easily summarized for the Regional Program.

Inter-basin transfers of supplies and resources are typical features of a regional plan. These features in the NAR Regional Program are supplemented by additional information on the outstanding regional characteristics of the planning elements found in the Area Programs. There are, for instance, those needs of an Area that grow rapidly during the planning period in comparison to the growth rate of that need in the other Areas. It may be that these rapidly growing needs of the Area should be emphasized in future studies or projects. Criteria were developed and applied to this type of information on regional characteristics for deriving Study recommendations.

The derivation of the comparisons among the planning elements was achieved by a simple computer program print-out of rankings of all the needs and costs by size, growth rates and per capita size. The Areas with the largest, largest per capita and fastest growing needs are pointed out in Chapter 8. This same information is presented for devices and benefits when possible.

Throughout the Regional Program those needs and devices are pointed out which were considered during plan formulation to be important or key. The words important and key are used to describe characteristics of needs and devices for which no terms have become common. These characteristics are subjective appraisals of a need or device within an Area made by members of the Work Group or NAR and agency staffs during the formulation of the Area Programs. Areas do not necessarily have key and important needs and devices at this level of study since the appraisals are made from a Regional viewpoint.

Important needs in an Area must be fulfilled before an Area's recommended mixed objective can be achieved. Key needs are those which must be fulfilled before other needs that are dependent upon that need can be fulfilled. Needs may be important because of their large sizes or fast growth rates. Needs are identified as key because of the integral part they play in the fulfillment of other needs. In this sense water quality is key to water recreation.

A device may be important in an Area because the need it fulfills is large or growing fast; it may fulfill many needs; it may have no substitutes; it may be able to greatly change the level of important or key needs; or it produces large benefits or costs. Key devices are those which must be used so that other devices may succeed.

The available benefits and costs of the Regional Program are described need by need. The Areas are listed which have the largest benefits and costs for each need.

Making Study Recommendations

The Coordinating Committee for the NAR Study adopted criteria for making recommendations as the Study product. The recommendations and criteria are in accordance with the Authorization of the Study and with the directives of the Water Resources Council.

The Coordinating Committee stated that the Report will recommend:

1. that individual mixed objective plans be adopted as framework plans and that these plans be the starting points for future detailed basin or project planning,

2. that priorities be established for detailed river basin studies to be initiated at specific times, in specific basins,

3. that individual project studies be undertaken in those Areas not listed in 2, above, and that each project study be measured against the corresponding basin framework plan,

4. that priorities be established for special emphasis to be placed on specific planning elements in subsequent basin or project studies,

5. that a time schedule be established and procedures recommended for updating the Plan and for repeating the Plan Formulation process,

6. that priorities be established for research and that special purpose studies be conducted in certain fields to fill gaps of knowledge identified in this Study.

The alternative planning elements, the Area Programs, and the Regional Program are steps in deriving these recommendations. The recommendations were first taken from suggestions of Work Group members during the Plan Formulation process and from information in the Area and Regional Programs that revealed problems and deficiencies.

Specific criteria were developed to regulate the formation of these recommendations. The first recommendation (Recommendation No. 2 in Chapter 10) is comprised of that level of the NAR Study results that most closely corresponds to the configuration of the Region's individual basins and that also contains the type of data that can serve as the best focus for future basin or project planning.

The second recommendation (Recommendation No. 4a in Chapter 10) consists of those Areas where the level of needs are soon to be beyond the ability of resources to fill them and which have not had recent feasiblity studies. These need levels are determined by first comparing each Area's needs by their sizes, growth rates, per capita sizes, importance and how key they are. Those Areas with large numbers of needs that rank high by these characteristics and with low per capita limits of developable water are chosen for study.

The third recommendation (Recommendation No. 4c in Chapter 10) is made up of those Areas which also have large numbers of needs that rank high by the characteristics listed under the second recommendation but which have low total limits of developable water rather than low per capita limits of developable water.

Recommendation number four (Recommendation No. 4c in Chapter 10) consists of those needs and devices which are listed most often as being important or key within the Area Programs. The need list, however, is slightly modified by moving up some of the needs which are simultaneously very large, rapidly growing and very large on a per capita basis.

The fifth recommendation (Recommendation No. 4d in Chapter 10) calls for the plan formulation process to be repeated whenever significant new data become available or when assumptions and constraints used in the present Study are significantly changed.

The last of the recommendations (Recommendations No. 1 and 5 in Chapter 10) arose from all procedures and results of the NAR Study. Special studies are recommended for those planning procedures and activities found to be inadequate or misunderstood and for those needs and devices which create problems and conflicts in achieving any of the mixed objectives of the Areas. Needs or devices with very large costs in relationship to benefits are examples as well as devices which people do not want to use.

CHAPTER 6

ALTERNATIVE NEED LEVELS FOR WATER AND LAND RESOURCES

Three objectives and fifteen water and water related needs have been analyzed in this Study. The three objectives used are: increasing national income; increasing regional development; and improving environmental quality.

Each need and the methods and assumptions used in deriving estimates of each need are described in this Chapter. Need estimates were first derived from various population and economic projections and then modified by consideration of the objectives. The results are three sets of estimates, one estimate for each of the three objectives, for all those needs where differences due to objectives were determined. The estimates are given in one or more measurable quantities -- such as million gallons per day of water or acres of land -- for each need and each benchmark year.

The National Income objective is the provision of increases in the national income through investment in water resources development. This objective (called National Efficiency in some of the NAR Appendices) is attained to the extent that water resources system outputs meet demands expressed in market terms or in terms of statistically reconstructed markets.

An example of a market demand for a system output is industrial demand for water supply; an example of demand in terms of a statistically reconstructed market is demand for recreation outputs not sold on a market basis.

Meeting demands of this type has been the traditional objective of water resource development, and its attainment has usually been measured by counting "primary" benefits. Another way of defining the objective is to say that it represents the best allocation of economic resources in market terms.

The Regional Development objective of framework planning is the attainment of some desired pattern of regional income or development through water resources investment. This objective is attained to the extent that water resources investment provides specified regional income flows or specified patterns of regional development.

An example of a regional objective is the desire to increase the incomes of the indigenous residents of an Area through water resources investment. Another example is the desire to increase the total output of a designated region. In general, patterns of this kind are not the natural result of investing to attain the objective of national income growth or other objectives. Thus, attaining a given Regional Development objective ordinarily results in a lesser degree of attainment of other objectives than would occur in the absence of the regional goal. It may also involve the shifting of development that would have occurred in another region to the region in question.

The regional goals used in plan formulation for the North Atlantic Region have evolved from consideration both of desired regional patterns and of planning results indicating what regional patterns are achievable or may be stimulated through water resources development. (The Coordinating Committee was involved with one regional consideration from the start of planning since part of Appalachia is included in the North Atlantic planning Region.) Regional considerations have been involved to some extent in water resource planning as "secondary" benefits in past studies. In this framework plan, they are involved more explicitly in the process of plan formulation.

The Environmental Quality objective of framework planning is the improvement of the quality of the environment through water resource investment in the North Atlantic Region. This objective includes not simply preservation but, perhaps more important, positive measures to create an improved living environment.

The intention of including this objective is to insure that the effects of water resource development on "human ecology," are carefully defined and evaluated. The extent to which the Environmental Quality objective is attained cannot be readily expressed in the terms that might be used for the National Income and Regional Development objectives. But there are systematic ways in which environmental quality effects can be assessed.

It was possible for the Coordinating Committee to find a broad range of agreement on whether certain effects were favorable to the quality of the environment, and what the relative importance of various effects was, both in terms of other Environmental Quality effects and in terms of the other objectives of planning. The relationship between water resource development and environmental quality differs among the Areas of the Region. For example, problems of environmental quality differ as between relatively urban and relatively rural areas. The open expression of the Environmental Quality objective represents a comparatively new direction in water resources development, although it has always been present in the form of supplementary comments in project reports, particularly with respect to the preservation aspect of the objective.

The fifteen water and water related needs include:

publicly supplied water
industrial self-supplied water
rural water supply
irrigation water
power plant cooling
hydroelectric power generation
navigation
water recreation
fish and wildlife
water quality maintenance
flood damage reduction
drainage control
erosion control
health
visual and cultural environment

Nine projection points, one for each of the objectives for each of the benchmark years, have been made for most of these needs. These alternative projections for each of the 21 Areas are given in tables in the Area Program Annex of this Report. A summary of these alternative need levels is shown in Table 33. The specific methods and assumptions underlying the estimates are given here for each of these fifteen needs.

PUBLIC WATER SUPPLY

Needs for public water supply are the future amounts of water, in millions of gallons per day, estimated to be necessary to meet projected demands on all public water supply systems.

Public water supply projections for the 21 Areas are a function of the population served by central water systems and the per capita income in each of the Areas. An equation relating those functions was developed for the NAR and applied to each of 50 sub-areas in the computer Demand Model. Projected requirements include publicly supplied water for domestic, commercial, municipal and industrial purposes that are served by central supply systems.

TABLE 33
SUMMARY OF ALTERNATIVE LEVELS OF NEEDS, NAR

NEEDS-cumulative			Pres.
Publicly Supplied Water		(1000 mgd)	5.5
Industrial Self-Supplied Water		(1000 mgd)	3.9
Rural Water Supply		(mgd)	400
Irrigation Water:	agriculture	(1000 afy)	200
	non-agriculture	(1000 afy)	100
Power Plant Cooling:	withdrawal, saline	(cfs)	23000
	brackish	(cfs)	12000
	fresh	(cfs)	10000
	consumption, brackish	(cfs)	120
	fresh	(cfs)	120
Hydroelectric Power Generation		(1000 mw)	5
Navigation:	commercial	(m. tons annually)	600
	recreational boating	(m. boats)	1.6
Water Recreation:	visitor days	(m.)	(21)
	stream or river	(1000 miles)	(21)
	water surface	(m. acres)	(21)
	beach	(1000 acres)	(21)
	pool	(m. sq. ft.)	(21)
	land facilities	(1000 acres)	(21)
Fish & Wildlife:	sport fishing man-days	(m.)	100
	surface area, lake	(acres)	(12)
	stream	(acres)	(11)
	access, fresh	(1000 acres)	(21)
	salt	(1000 acres)	(11)
	anadromous	(acres)	(19)
	piers	(1000 feet)	(9)
	hunting man-days	(m.)	38
	access	(1000 sq. mi.)	(21)
	nature study man-days	(m.)	60
	access	(1000 acres)	(15)
Water Quality Maint.:	non-industrial	(m. PEs)	44
	industrial	(m. PEs)	70
Flood Damage Reduction:			
avg. ann. damage,	upstream	(m.$)	55
	mainstream	(m.$)	80
	tidal & hurricane	(m.$)	61
Drainage Control:	cropland	(m. acres)	1.2
	forest land	(1000 acres)	(0)
	wet land	(1000 acres)	(1)
Erosion Control:	agriculture	(m. acres)	15
	urban	(m. acres)	8
	stream bank	(1000 mi.)	(21)
	coastal shoreline	(1000 mi.)	(12)
Health: vector control and pollution control			(21)
Visual and Cultural			
landscape maintenance,	unique natural	(sq.mi.)	11000
	unique shoreline	(mi.)	90
	high quality	(sq.mi.)	3800
	diversity	(sq.mi.)	(10)
	agriculture	(sq.mi.)	(7)
landscape development,	quality	(sq.mi.)	(6)
	diversity	(sq.mi.)	(1)
	metro. amenities	(mi.)	(1)
	met. amenities	(sq.mi.)	(12)

All arrows indicate that numbers are identical for indicated objectives.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	6.9	9.6	13.1	7.2	10.6	15.7	7.2	10.8	16.1
	7.0	11.8	17.9	7.0	12.4	20.0	7.2	13.2	22.2
	←			570	790	720			→
	1700	4700	5800	500	500	500	1700	4700	4700
	300	490	720	270	460	720	280	470	720
	43000	110000	190000	43000	117000	213000	43000	97000	170000
	30000	52000	54000	30000	61000	97000	30000	66000	105000
	11000	8000	4000	11000	50000	94000	11000	29000	48000
	280	750	1160	280	540	360	280	660	1380
	450	770	1280	450	1120	2340	450	1380	2750
	←			15	42	100			→
	700	900	1300	800	1100	1700	800	1200	2000
	←			2.1	3.5	6.0			→
	900	1500	2500	800	1300	2300	900	1500	2500
	5.8	8.2	11.3	1.9	2.7	3.7	2.9	4.0	5.6
	1.6	2.4	3.3	0.4	0.7	0.9	0.9	1.3	1.7
	16	22	31	5	7	11	10	13	18
	270	380	530	100	140	210	170	240	330
	1020	1400	1990	180	260	370	370	500	690
	←			110	140	180			→
	←			75000	142000	248000			→
	←			19000	32000	43000			→
	←			2.0	4.5	7.4			→
	←			5.4	15.2	26.8			→
	←			890	1220	1590			→
	←			140	400	700			→
	←			43	53	66			→
	←			5	18	29			→
	←			70	88	109			→
	←			150	410	730			→
	←			56	70	86			→
	←			140	300	620			→
	←			82	145	275			→
	←			130	260	530			→
	←			96	181	359			→
	1.8	2.7	2.9	1.6	2.4	2.5	1.8	2.7	2.9
	0	170	670	0	170	670	170	670	2180
	(0)	(0)	(0)	(1)	(0)	(0)	(0)	(0)	(0)
	19	23	23	17	19	19	19	23	23
	11	15	20	9	11	15	11	15	20
	0.54	1.63	2.71	0.11	0.38	0.65	0.27	0.81	1.35
	1.14	2.36	2.55	0.02	0.07	0.12	0.05	0.14	0.24
	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)
	26000	26000	26000	26000	26000	26000	Same	as	EQ
	1360	1360	1360	1240	1240	1240	Same	as	EQ
	11200	18500	25900	11200	18500	25900	Same	as	EQ
	3500	6900	10300	2800	5100	7400	Same	as	EQ
	7300	7300	7300	7300	7300	7300	Same	as	EQ
	1000	2000	3000	500	1000	1500	Same	as	EQ
	300	300	300	150	150	150	Same	as	EQ
	2	2	2	2	2	2	Same	as	EQ
	670	670	670	410	670	670	Same	as	EQ

The portion of population served by systems for the base year was obtained from historical data. Estimates of the portion of population served were projected for each sub-area for each benchmark year. It was assumed that the portion of population served would rise during the study period due to the anticipated increases in urbanization and suburbanization. The projected total populations and per capita incomes used to estimate public water supply needs were derived from projections in Appendix B, Economic Base.

The procedure for developing public water supply projections was incorporated in the Demand Model used to project future withdrawals. Utilizing the median series population and per capita income projections from Appendix B yielded results for the National Income objective. For the Regional Development objective, the same population projections were used, but a higher level of per capita income was assumed which resulted in larger projections for public water supply. For the Environmental Quality objective, both populations and per capita incomes lower than the National Income objective were assumed which yielded lower public water supply projections.

INDUSTRIAL SELF-SUPPLIED WATER

The need for industrial self-supplied water is the projected amount of water necessary to meet the demands of the 19 major water-using industry classes that obtain water from their own sources of supply.

Industrial water use in the North Atlantic Region is a function of the gross industrial output of the Region. A mathematical relationship between existing water use and gross output was established from the data contained in the Census of Manufacturers and projections of the future relationship were made utilizing estimates of future water use technology and individual industrial trends. This relationship involved: distribution of gross output among the various industries and the 50 sub-areas; and development of regional water use coefficients relating gallons of water required to an industry's output in dollars on a sub-area basis. The development of coefficients also entailed separating the water use for each industry into total, fresh, brackish and waste water components, and further separating these components into self-supplied and publicly supplied fresh water. These mathematical relation ships together with an economic productivity model (input-output table) of the Region are a part of the Demand Model.

Several technological changes were projected to occur in the Region's industry that would change water use. For those industries in which water use is mostly for the sanitary need of their employees, water use coefficients are based on the estimate of employees in the future. This implies a reduction in water use per dollar of output because the productivity per employee is projected to rise. For those industries in which water is a relatively small part of the manufacturing process, such as the machine and electrical industries, the water coefficients were considered constant. In the six heavy water using industries which are of importance in the Region, projections of the water coefficients are based on industry estimates of future technology. For the Food, Textile, Petroleum Refining and the Primary Metals industries, water use improvements of 5 percent were projected for the 1964 to 1980 period, 5 and 9 percent, respectively, for the 1980 to 2000 and 2000 to 2020 period. For the Paper industry improvements of 10, 18 and 15 percent and for the Chemical industry improvements of 15, 26 and 21 percent were projected for the 1964 to 1980, 1980 to 2000 and 2000 to 2020 periods.

The Gross National Product figures for the median projection in Appendix B were used to determine the present industrial use as well as the National income objective needs for the future.

For the Regional Development objective, the Gross National Product resulting from a higher productivity level was used.

For the Environmental Quality objective the Gross National Product resulting from a lower population series was used.

RURAL WATER SUPPLY

The need for rural water supply is the sum of projections of livestock water use and rural self-supplied domestic water use.

Livestock water requirements are based upon gallons of water for projected animal products or livestock population. Rural domestic water supply is based upon estimated per capita rates of future rural populations.

Alternative need levels for objectives were not developed for rural water supply. Variations in animal product, livestock numbers and rural per capita use would seem to be slight under the various objectives. All rural water supply was assumed to be derived from individual wells and, therefore, assigned to ground water for fulfillment.

IRRIGATION WATER

Need for irrigation water is the projected amount of water necessary to satisfy plant moisture requirements for agricultural production and for commercial, industrial, institutional lawns and golf courses.

Historical observations were fitted to a trend line to project future levels of agricultural irrigated land. Water requirements were projected using a Blaney-Criddle Method which emphasizes climate, rainfall, carry off moisture and plant growth characteristics.

Non-agricultural irrigation for commercial, industrial and institutional lawns was projected using a cluster analysis for those areas showing a trend in land use from rural to urban. Golf course irrigation is projected using a regression of acres per thousand people and income, along with judgmental decisions concerning the extent of irrigation.

The portion of the irrigation water demand that is likely to be satisfied from individual wells was estimated for each sub-area. This amount was specifically assigned to ground water.

National Income levels are based upon the assumption that only high value, specialized crops will be irrigated. Regional Development levels assume that marginal crops will be irrigated. Environmental Quality levels are the same as Regional Development levels until 2020 when Environmental Quality would become higher for irrigating marginal crops held in production to maintain open space.

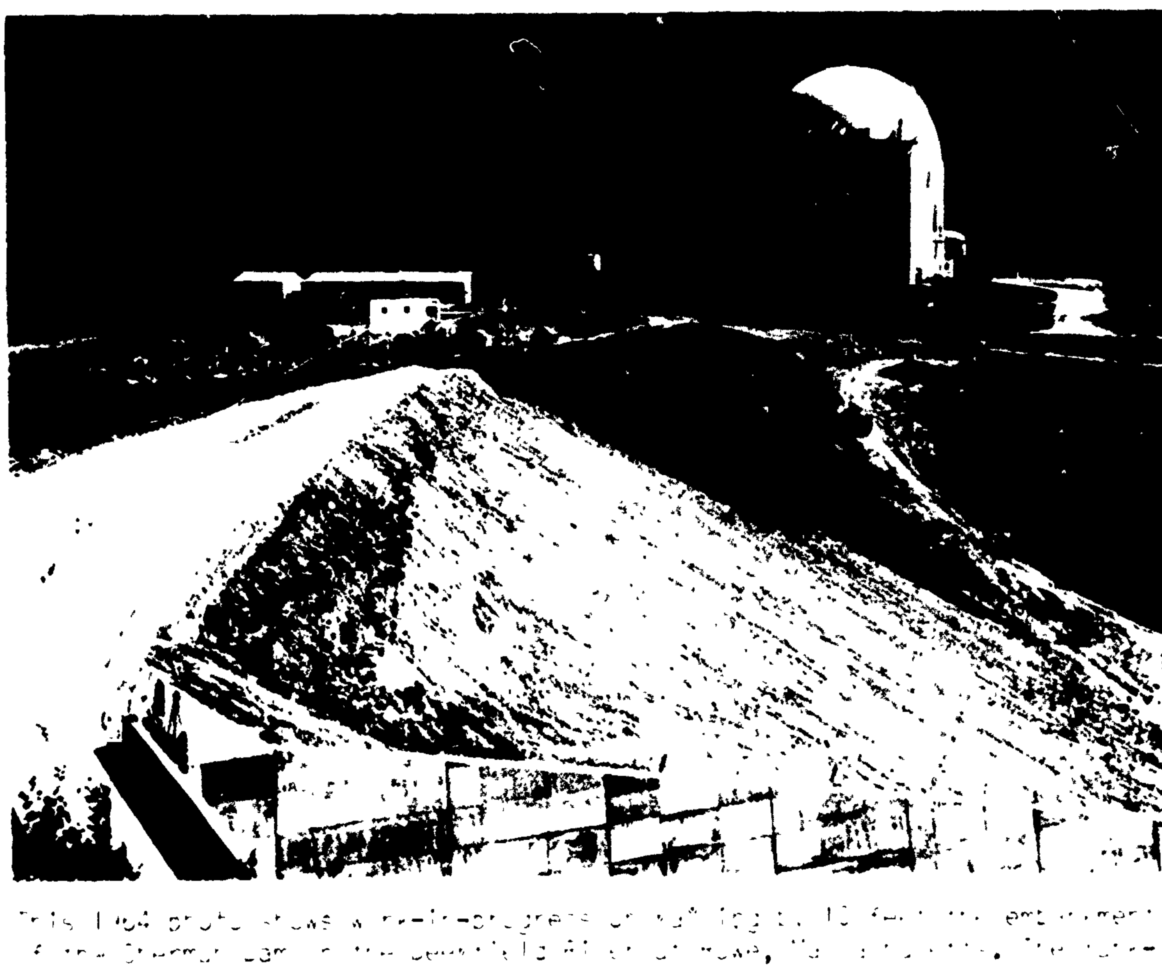
POWER PLANT COOLING AND HYDROELECTRIC POWER GENERATION

Needs for power plant cooling are projections of withdrawal and consumptive requirements for the cooling of thermal power plants. The need for water for hydroelectric power generation occurs mainly during peak periods of power demand and is expressed as megawatts to be produced.

Power plant cooling needs for National Income objective are based upon studies that have been made jointly by the public utility industry and the Federal Power Commission. Projections of the amount and type of technological change in power production, water requirements, recirculating efficiencies and power station location were made to convert power projections to water requirements. Fresh, brackish and salt water are considered for use. For the purposes of power plant cooling use, fresh water is defined as containing less than 500 parts per million (ppm) of dissolved solids. Brackish water is defined as water with a salinity between 500 ppm and 15,000 ppm and saline water is greater than 15,000 ppm.

The Regional Development objective assumes a redistribution of power plants based upon the enhancement of the economic well-being of those Areas which have been projected by economic studies to be most likely to benefit from location of a power plant facility. Environmental Quality assumes that "exotic" non or low heat-emitting generating plants will replace some conventional thermal plants and that a larger proportion of new thermal facilities will be located in coastal areas with appropriate ecological safeguards

Hydroelectric power needs are primarily for pumped storage, with no variations in total capacity among objectives. Site availability is the main determinant of the use of this type



This 1964 photo shows work-in-progress [illegible]

of power source. Sites are chosen on the basis of economic advantage constrained to provide adequate peaking capacity for the whole Region. Peaking needs are estimated generally as 10 percent of total power needs.

NAVIGATION

Needs for navigation are of two types, commercial and recreational. Commercial navigation needs are based upon the projected tonnage of commercial cargo transportation. Recreational boating needs are the projected levels of boating activity for recreation expressed in participation days per person.

Commercial navigation projections were determined for the major waterborne commodities of the North Atlantic Region, and these were used to determine the total projected waterborne commerce of the Region. Projections of these major commodities were based on information and projections contained in studies undertaken by various Federal and non-Federal agencies and organizations and modified through discussions with knowledgeable individuals. A range of values is presented which becomes broader in the more distant future as the degree of possible error increases. It is considered that the range will account for future technological innovation which cannot be foreseen at this time. In addition to Regional forecasts, projections have also been derived for the major ports in each Area.

The upper portion of the projected range of commerce is expected to be achieved under a program emphasizing Regional Development and the lower portion of the range reflects the Environmental Quality objective. The National Income projected commerce is between these limits and tends toward the higher or Regional Development projections in most Areas and for the Region.

Recreational boating needs have no variation by objectives and are presented as projected numbers of registered craft and total craft. Registered craft projections were obtained by applying to the population projections the present quantities of registered craft per capita in each state. Total recreational craft were estimated in the base year by assuming that presently there is a boat for each outboard motor estimated to be in use in each state by the National Association of Engine and Boat manufacturers. Projections assumed that participation days per capita and the ratio of registered craft to total craft remained the same as in the base year.

WATER RECREATION

Needs for water recreation are based on projected levels for swimming, camping, picnicking, boating, water-skiing, sailing, and canoeing.

Outdoor recreation needs are expressed as man/day participation rates in various recreational activities such as camping, hiking and sightseeing. The projections of participation rates for the National Income objective are based upon extrapolation of historical data of the activities and of the participation levels. The Regional Development and Environmental Quality variations are based upon varied assumptions of available leisure time, facilities, resources, and money.

FISH AND WILDLIFE

Needs for fish and wildlife are the same for all objectives and are based upon projections of different types of hunting, fishing and nature observation (bird watching, hiking) activities and upon the levels of wildlife management necessary to maintain these activities with minimum danger to ecological systems.

Needs for hunting man/days and angler man/days are based upon extrapolation of current trends of per capita participation applied to future population levels.

WATER QUALITY MAINTENANCE

The need for water quality maintenance derives from projected quantities of organic and inorganic pollutants in the Region. These pollutants are measured as the level of oxygen the pollutants would consume in the water on a per capita basis.

These projections of pollutants do not differ between objectives and are based upon projections of major pollution sources: industrial and non-industrial waste loads; septic tanks, cesspools and sewer system loads; mine drainage; and thermal discharges. The need for water quality maintenance is the change necessary in the pollution levels to maintain water quality standards.

Waste loadings are assumed to come from two sources, industrial and non-industrial, and are presented in terms of population equivalents (PE's). One PE is the amount of organic waste equal to that produced each day by one person. Other types of polluting substances which require consideration are infectious agents, plant nutrients, sediment and non-organic substances not specifically subject to biological treatment processes.

FLOOD DAMAGE REDUCTION

Needs for reducing flood damages are derived from projections of average annual monetary damages which are likely to occur in the future if present flood plain use patterns continue. The resulting estimates can be taken as upper limits of damages. Damages are projected for three categories: mainstream, upstream, and tidal and hurricane needs.

Mainstream and tidal and hurricane damages were assumed to begin at present levels as experienced under existing flooding conditions and flood frequencies, and to increase at a rate that is in proportion to the increased wealth of an area. Personal income was assumed directly related to reproducible wealth and the damageable assets in the flood plain were assumed to remain in the same proportion to wealth as in the base year.

Upstream flood damage reduction needs are based upon existing conditions, including areas inundated by floods, damageable properties, and probability of recurrence of floods, and upon projected economic activity of an area.

Flood damage reduction needs for the three objectives were derived by applying different criteria to the projected levels of damages. National Income levels were derived by watersheds in which direct and indirect floodwater damage reduction benefits exceed costs. Monetary benefits from a regional viewpoint caused Regional Development levels to be somewhat higher than National Income.

Environmental Quality levels assumed optimum protection would result from management of the entire flood plain and watershed protection, and visual quality in certain areas would be enhanced by water surface in multi-purpose reservoirs.

All damage projections included the effects of present conditions which were assumed to include flood damage reduction devices that are soon to be finished or implemented.

Hurricane Diane caused $130 million in damages in the Connecticut River Basin. This is Main Street in Winsted, Connecticut, a town of 10,000 which sustained damages of some $30 million in the August 1955 storm. (Department of the Army, New England Division, Corps of Engineers).

DRAINAGE CONTROL

Needs for drainage are given as the quantities of land that require drainage projects so that agriculture, forestry and development activities (economic uses of marshlands) can take place at levels appropriate for alternative objectives.

These needs are derived by projecting rates of past land treatment in agricultural activity and in major drainage activities such as river and outlet channels. The rates were determined from surveys of past experiences with some judgmental adjustments.

The National Income level assumes treatment of 80 percent of treatable cropland and of 15 percent of forest land by 2020. Regional Development assumes that all cropland needing drainage will receive treatment as soon as possible while 45 percent of the forest land needing treatment will receive it by 2020. The Environmental Quality objective has the National Income forest drainage projection levels and Regional Development agricultural drainage levels (for visual and cultural needs).

No numerical need is estimated for draining existing wetlands under any objective. There exist only a few specific sites in the NAR where drainage of wetlands for a development objective is possible without prohibitive ecologic damage.

EROSION CONTROL

Needs for erosion control are measured by the quantities of land that require erosion treatment so that agriculture and forestry activities and activities associated with shorelines and streambanks can occur at levels appropriate to alternative objectives.

Rates of erosion and sedimentation (soil loss per acre) are projected by the use of present rates of erosion -- based on soil type, topography, climate and cover data -- and a specific set of assumptions on the present and on an accelerated rate of land treatment.

The erosion control need used for the National Income objective assumes that lands highly subject to erosion require permanent vegetation, that full treatment is required for cropland and urbanizing land and that 12 percent of the major streambanks and critical shorelines will be controlled.

The erosion control need for the Regional Development and Environmental Quality objectives assumes that all erosive lands require land use adjustment, preservation or treatment and that 25 percent of streambanks and shorelines with erosion problems will be treated.

HEALTH

No numerical estimates have been prepared for health need levels. Needs for health are vector control, air pollution control, recreation sanitation, shellfish sanitation, public water supply treatment and liquid and solid waste management required to attain a level of good health for all people

VISUAL AND CULTURAL ENVIRONMENT

Needs for visual and cultural values are measured by the land areas that are significant for the maintenance or enhancement of landscapes, water quality and urban amenities desired by people in various activities such as recreation and daily travel.

The initial step in estimating these needs was a landscape inventory based upon visual indicators (natural and man-made). The next step was the definition and identification of visual and cultural aspects and characteristics of these landscapes. The third step was the definition of levels of needs using population concentrations; accessibility of the concentrated population centers to the areas of various qualities; and the relative abundance and scarcity of landscape types.

Landscape needs consist of the visual and esthetic qualities desired by people and defined as various combinations of land and land use patterns such as mountains, hills and flat lands and forests, marshes and urban areas. Urban amenities are those needs of people for visual and esthetic qualities in urban surroundings: fountains, water front vistas, parks, play areas and clean streets.

The differences between objectives are based on an increased emphasis on landscape enhancement under the Environmental Quality and Regional Development objectives over the level estimated under the National Income objective.

In using the need table it should be kept in mind that the amounts shown are cumulative estimates of varying accuracy. Figures for 1980 are likely to be far more reliable than those for the year 2000 and these are better than the figures for 2020. Needs given in water quantities are likely to be of a higher degree of accuracy than those given in other measures due to the availability of better projection techniques for those needs.

CHAPTER 7

ALTERNATIVE DEVICES FOR WATER AND LAND RESOURCES USE

Devices are the means by which water and water associated needs are fulfilled. Devices may act upon the resources or the demands and are usually called active devices when they modify the resource and passive devices when they change the demand. A reservoir which increases a river's low flow is an example of an active device; zoning a flood plain to keep out damageable property is an example of a passive one. Another way of grouping devices is by the things they affect.

There are devices that affect water, such as river intakes; those that affect land and water, such as local flood protection works; those involving only land, such as purchase of access to water; those that deal with ecology, like fish habitat management; and those that deal with the human environment as legislation does. Devices can further be divided into physical things, such as structures or natural wild streams, and non-physical activities such as management, institutional arrangements, research or education. And finally, devices can be classified by their use either as single purpose or multiple-purpose.

The largest and today still the most important group of devices deals with the resources themselves. These devices affect water, land or both or they control their use. Other devices are research, education and policy changes. The last two fields are just emerging but appear to be the devices that will be most important in the future.

Presented first in this Chapter in Table 34 are estimates of a total quantity for each device presently in use in the NAR and expected to be in use. The estimations of future device use are given as three sets of alternatives, one for each of the three Study objectives, and within each set are estimations for each of the three benchmark years. Figures are given when available for the devices and when not available the total numbers of Areas are indicated (in parentheses) within which the devices are used or are expected to be used.

Next follow descriptions of all the devices. These descriptions include the assumptions that were made for each, the methods used for estimating their future use and the needs that each will help fulfill. Most devices have at least some degree of multiple use but for convenience only the major needs fulfilled by each device are described.

Each of these descriptions is accompanied by a discussion of the capability and impacts of each device and about its present and expected level of technology. Benefits and costs are the result of the capabilities and impacts and are discussed for each device. Benefits and costs arise from the products of devices (water surface area for a dam, for example), from interactions between the devices and from interactions of the products of devices with their physical, biological or cultural environments. These benefits and costs may be expressed in monetary terms; in measurements and descriptions of the products and interactions; and in expressions of peoples' opinions of the products, devices and interactions.

Costs only are shown numerically in this Study. Other non-monetary product and interaction costs are described where possible. No numerical presentation is made for any of the benefits but descriptions are provided.

The twenty-three major categories of devices considered in the Study are listed as:

I. Resource Management

A. Water

storage facilities
withdrawal facilities
return facilities
conveyance facilities
quality control facilities
pumped storage facilities
desalting facilities
monitoring facilities

B. Water/Land

flood plain management
local flood protection
watershed management
erosion protection
drainage practices
waterway management

C. Land

land controls
land facilities

D. Biological

habitat management
fishways
stocking

II. Research

III. Education

IV. Policy Changes
A. Water Demand and Allocation Changes

B. Project Operation Changes

Many specific and individual devices have been considered in this Study. For instance, the specific types and numbers of reservoirs and their possible individual sites have been considered for each Area. However, since the devices are used to fulfill needs only on a generalized basis, estimations for fulfillment of the needs are only made as total quantities of water or associated services. For example, only required total storage is presented rather than the specific number of reservoirs. Similarly, water quality maintenance needs are given by total quantity of certain types of treatment measured in population equivalents rather than by a specific number and location of treatment plants. The estimations of device use presented in Table 34 are for the NAR as a whole. These figures are broken down into the 21 Areas in Annex 1, Area Programs.

STORAGE FACILITIES

Surface storage devices are considered to be multiple purpose devices that may serve up to five possible withdrawal needs – publicly supplied water; industrial self-supplied water, rural water, irrigation and power plant cooling – and may serve up to eight instream needs – navigation, hydroelectric power generation, water recreation, fish and wildlife, visual and cultural, health, flood damage reduction and water quality maintenance.

Surface storage for flood damage reduction, instream hydroelectric generation water quality maintenance (low flow augmentation) needs has been considered on a single purpose basis but is either additive to other uses as in the case of flood control or can be incorporated into other flow regulation needs.

Provisions have been made for minimum instream flows and outflows, including maintenance of salt fronts in some cases, but flow augmentation for water quality maintenance, such as in lieu of treatment, is not provided in the supply models.

Practical limits of development of storage facilities were determined. Site availability rather then hydrologic considerations established these limits.

Farm ponds have been considered in the Study for irrigation and rural water supply but are considered to be insignificant on a regional basis.

Single purpose reservoirs have also been considered to meet such needs as localized storage for municipal water supply.

TABLE 34
SUMMARY OF ALTERNATIVE LEVELS OF DEVICES, NAR

DEVICES-incremental		Purposes	
I. Resource Management			
A. Water			
Storage Facilities ϕ			
reservoirs, upstream	(1000 af)	Irrig,Rec,FW,VC	
mainstream	(1000 af)	PS,FW,VC,Rec,WQM	
Withdrawal Facilities			
intakes & pumping, fresh	(mgd)	PS,Ind,Pow,Irrig	
brackish	(mgd)	Ind	
estuarine	(mgd)	Pow	
ocean	(mgd)	Pow	
wells	(mgd)	PS,Ind,Rur,Irrig	
Conveyance Facilities			
interbasin diversions, into	(mgd)	PS	
out of	(mgd)	PS	
Quality Control Facilities			
temperature, cooling towers & ponds		WQM,Pow,Rec	
chemical/biological			
potable water treat plants	(mgd)	PS	
waste treatment plants			
secondary (85%) (m. PE removed)		WQM,VC,Rec	
secondary (90%) (m. PE removed)		WQM,VC,Rec	
advanced (95%) (m. PE removed)		WQM,VC,Rec	
effluent irrigation		WQM,VC,Rec,Irrig	
nutrient control		WQM,VC,Rec	
stormwater discharge control		WQM,VC,Rec	
acid mine drainage control		WQM,VC	
septic tank control		WQM,VC,Rec	
separate combined sewers		WQM,VC,Rec	
Pumped Storage		HPG	
Desalting Facilities			
Monitoring Facilities			
B. Water/Land			
Flood Plain Management			
upstream	(1000 acres)	FDR,VC,FW,Rec	
mainstream	(1000 acres)	FDR,VC,FW,Rec	
Local Flood Protection			
ocean	(projects)	FDR	
river	(projects)	FDR	
flood control channels	(mi.)	FDR	
Watershed Management	(1000 acres)	FDR,VC,Drn,FW,Rec	
Erosion Protection, land treatment		Ern	
coastal shoreline		Ern,Rec,VC	
river shoreline		Ern	
Drainage Practices		Drn,FW	
Waterway Management			
navigation channel improvement		Nav	
debris removal			
recreation boating facilities		Nav,Rec	

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pc
ϕ Flood control storage not included.

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	1120	2180	790	210	80	40	1120	2180	40
	610	1310	410	720	1710	940	750	1750	1030
	2900	5000	6600	3000	5800	9100	3100	6400	10600
	2600	3800	4800	2600	4400	6100	2700	4900	7200
	(6)	(11)	(10)	(6)	(11)	(12)	(6)	(11)	(12)
	(11)	(13)	(14)	(11)	(13)	(14)	(11)	(12)	(14)
	1600	2600	2100	1300	2100	2100	1700	3000	2200
	60	440	1090	80	690	1670	80	700	1830
	60	440	1090	80	690	1670	80	700	1830
	(13)	(14)	(18)	(10)	(12)	(16)	(11)	(15)	(20)
	400	1700	2500	500	2200	3500	500	2200	3900
	←			55	0	0			→
	←			120	340	640			→
	←			6	17	35			→
	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
	(20)	(20)	(20)	(8)	(8)	(8)	(10)	(10)	(10)
	(19)	(15)	(15)	(9)	(5)	(5)	(10)	(6)	(6)
	(3)	(1)	(0)	(3)	(1)	(0)	(3)	(1)	(0)
	(9)	(9)	(9)	(5)	(5)	(5)	(6)	(6)	(6)
	(19)	(14)	(14)	(8)	(4)	(4)	(9)	(5)	(5)
	←			(7)	(11)	(13)			→
	←			(0)	(0)	(0)			→
	←			(0)	(0)	(0)			→
	1260	3260	1570	250	50	170	210	60	170
	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)
	11	3	0	11	7	0	11	7	0
	180	190	130	130	190	90	210	180	70
	580	330	300	840	1540	1850	2070	2140	80
	8600	17100	17100	4100	4600	2900	6200	4300	1700
	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)
	(13)	(13)	(13)	(10)	(11)	(11)	(11)	(11)	(11)
	(21)	(21)	(21)	(18)	(21)	(21)	(21)	(21)	(21)
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	(1)	(0)	(0)	(13)	(14)	(8)	(13)	(14)	(8)
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)

TABLE 34 (cont.)

DEVICES--incremental (cont.)	Purposes	
C. Land		
Controls		
fee simple purchase (buying) (sq.mi.)	VC,Rec,FW	
fee simple purchase (buying) (mi.)	VC,Rec,FW	
purchase lease (sq.mi.)	VC,Rec,FW	
easements (sq.mi.)	VC,Rec,FW	
deed restrictions (sq.mi.)	VC,FW	
tax incentive subsidy (sq.mi.)	VC,FW	
zoning (sq.mi.)	VC,FW,Rec	
zoning (mi.)	VC,FW,Rec	
zoning and/or tax inc. subs. (sq.mi.)	VC,FW,Rec	
zoning and/or tax inc. subs. (mi.)	VC,FW	
Facilities		
recreation development	Rec	
overland transportation to facility	Rec	
parking and trails	FW,VC,Rec	
site sanitation and utilities	VC,Rec	
D. Biological		
Habitat Management, fish	FW	
wildlife	FW	
Fishways	FW	
Stocking, fish	FW	
wildlife	FW	
Water Quality Standards Enforcement	FW,WQM	
Insect Control	Hlth,Rec	
II. Research	WQM,Pow,Hlth,Rec	
III. Education		
IV. Policy Changes		
Water Demand and Allocation Changes		
pricing and rationing		
non-condenser power facilities	Pow	
re-circulation (internal)		
Project Operational Changes		
remove restrictions		
remove project	FW	
add new project needs	Rec,FW	
change project design load	Rec	
V. Others		
Upstream Flood Control Storage (1000 af)	FDR	
Mainstream Flood Control Storage (1000 af)	FDR	
Waste Water (mgd)	Ind	
Shell Fish Protection	Hlth	
Hydroelectric Generation Storage	HPG	
Septic Tank Elimination	Hlth	

	ENVIRONMENTAL QUALITY			NATIONAL INCOME			REGIONAL DEVELOPMENT		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
	20030	5130	5130	9340	80	50	Same	as	EQ
	1210	0	0	780	0	0	Same	as	EQ
	5400	0	0	2600	700	500	Same	as	EQ
	4500	4500	4500	2200	1800	1800	Same	as	EQ
	100	0	0	0	50	0	Same	as	EQ
	0	0	0	550	550	550	Same	as	EQ
	3800	0	0	5300	600	600	Same	as	EQ
	60	0	0	350	0	0	Same	as	EQ
	2400	2100	2100	14600	6400	6400	Same	as	EQ
	0	0	0	32	0	0	Same	as	EQ
	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)
	(15)	(15)	(15)	(13)	(13)	(13)	(16)	(16)	(16)
				(21)	(21)	(21)			
	(21)	(19)	(19)	(21)	(20)	(19)	Same	as	EQ
	←			(21)	(21)	(21)			→
	←			(21)	(21)	(21)			→
	←			(12)	(13)	(13)			→
	←			(15)	(15)	(15)			→
	←			(19)	(19)	(19)			→
	←			(21)	(21)	(21)			→
	←			(21)	(21)	(21)			→
	(7)	(16)	(6)	(5)	(13)	(14)	(6)	(12)	(4)
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	(0)	(13)	(18)	(0)	(0)	(0)	(0)	(0)	(0)
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	←			(13)	(14)	(14)			→
	(13)	(14)	(16)	(15)	(15)	(15)	(16)	(16)	(16)
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	1210	830	730	680	880	620	1060	840	540
	500	390	5	620	1030	460	640	1030	460
	140	310	600	140	340	720	150	380	820
	←			(1)	(1)	(1)			→
	(0)	(2)	(0)	(0)	(2)	(0)	(0)	(2)	(0)
	←			(1)	(1)	(1)			→

Fisheries enhancement and future water supply for the Greater Hartford Metropolitan Area are two of many attributes of multiple-purpose Colebrook River Lake on the West Branch Farmington River in Connecticut. This project is a vital link in the Connecticut River Basin flood control system. (Department of the Army, New England Division, Corps of Engineers).

Underground storage was considered as an alternative primarily in combination with ground water management techniques rather than as a separate device.

Technology for storing water is well established. Reservoir and dam designs can be so extensively varied as to meet a variety of needs at once while minimizing adverse impacts. Such structures, however, are large in relation to their surroundings and may have significant beneficial or costly impacts whether they be of an esthetic, ecological or cultural nature.

The net value of a storage facility will depend upon its design and operating policies that consider all types of impacts upon the man-made and natural surroundings. Visual impact, for instance, is most likely to be of positive value in mountains or steep hills where open views are lacking. The visual impact will most likely be damaging in low hills or flat country where the flat water does not provide a contrast. Cultural impacts from storage facilities are most likely to occur near population centers.

Costs and benefits of such facilities must be related to the specific site, detailed design and operating procedures. There appear to be no significant technologic advances that are likely to soon change major storage facilities.

Storage facilities are most beneficial under a National Income or a Regional Development objective as they most easily aid economic activities. Under an Environmental Quality objective the costs of these facilities are high as they disrupt environmental resources and they are generally limited in their use.

WITHDRAWAL AND RETURN FACILITIES

Water intake and return facilities are required for any withdrawal need. The primary sources of withdrawals are rivers, lakes, estuaries, the ocean or ground water. River and lake intakes will be the primary device to fulfill fresh water needs.

Estuarine intakes are not favored in this Study since the environmental consequences of increased intakes in bays and river mouths can be catastrophic. The biological relationships of estuaries are very sensitive to physical and chemical changes caused by intakes. Ocean intakes, however, will probably be increasingly used for power plant cooling and industrial needs. This increase in use of saline water intakes will be especially true for Areas

in which the Environmental Quality objective is emphasized and fresh water is preferred for high quality water supplies, recreation and similar needs.

Wells will have increasing use in the NAR. This source of water is very site dependent and large flow wells are fairly unusual in the NAR. Well fields can often be employed, however, to obtain a desired flow.

Ground water in the NAR must be carefully used in two cases.

(1) when it is closely associated with the river water so that ground water withdrawal is almost the same as surface withdrawal because of interconnections, and

(2) when the wells are close to coastal areas so that salt water intrusion is a problem.

Complete ground water management is necessary in both cases.

Ground water recharge is presently being used in some portions of the Region, especially Area 13, and should see increasing use in geologically similar portions of the Region to maintain salt water fronts and ground water levels.

The weirs, intakes, pumping stations and wells that remove surface or ground water from its natural conveyance are part of a well established technology. The existing devices now in use are efficient and future technology would provide only marginal gains in efficiency. In the field of site specific design, however, greater improvements are possible. Visual, cultural and ecological impacts of these devices are generally very localized, of relatively little importance and where negative, easily mitigated. The exceptions are large well fields in flat and coastal landscape where ecological impact may be high due to changes in the water table or intrusion of salt water into aquifers. Specific site studies can produce designs to keep such adverse impacts to a minimum.

Devices to return water into surface water bodies are similarly a part of a fully developed technology. Effects here are also localized and site specific. Quality control of the returned waters is a major problem. Devices to return water to the ground - recharge facilities - are part of a developing technology. The problem here is more of applying known technology than the need for a new one.

Significant improvements in recharge technology and its application appear feasible and their application practical. The environmental impacts of recharge devices are significant visually because of their size and extent and ecologically due to their changing the groundwater level and water quality. Withdrawal and return facilities are compatible with all objectives.

CONVEYANCE FACILITIES

Every time water withdrawal occurs conveyance facilities are required to transport the water to the point of use. Pipelines and pumping stations are the most commonly used conveyance facilities. Tunnels, aqueducts and large pipelines will be coming into increasing use in the NAR as water shortages increase and interbasin diversions are required for the larger municipal areas or for entire river basins.

Localized conveyance facilities for local distribution and municipal water systems are not considered at this Study level.

Water conveyance technology has a long history. In spite of this, technological changes of significant impact can be expected in both the near and farther future. Water conveyances are used within localized systems and over long distances connecting basins and distant regions. Conveyance devices can be used anywhere, their selection usually governed by economic and environmental considerations. Primary environmental effects are normally significant only near the facility. Some conveyances may cover hundreds of miles and their impacts generally diminish as the devices are placed deeper below the surface. Tunnels, therefore, have fewer environmental impacts than pipelines with their visible clearcut rights-of-ways and these have less impacts than open channels. The more important impacts of conveyance facilities are the cultural and ecologic impacts due to removing water from one area for the benefit of another. These impacts are always present and often significant, can be both beneficial and adverse and, therefore, must always be considered in the decision process.

Conflicts will probably become larger over rights-of-way for conveyance facilities as environmental and ecological values are given greater weight in planning the installation of such facilities. New uses of these rights-of-way will probably be sought for parks and for landscape diversity such as breaking up dense forests with openings that increase food and habitat for wild life.

Technological advances in tunnelling methods are likely in the near future, making tunnel construction faster and cheaper. These changes would reduce the local environmental impacts of large conveyance devices. The use of flexible undersea pipelines along ocean shores, and the use of towed freshwater filled bladders, are two methods that could be used to move large quantities of water along coast lines. Even further in the future may be such techniques as the admixture of chemical substances to allow faster and lower friction flow in pipes, and the towing of freshwater icebergs from the polar regions to water collecting plants. Depending on the specific situation – especially variations in the environmental impacts – conveyance facilities may be used to a degree under all objectives.

QUALITY CONTROL FACILITIES

Of the devices considered in the NAR Study, quality control facilities appear to be undergoing the greatest amount of technological change and increase in use. The planning and implementation of these facilities should be carried out in close coordination with the planning and implementation for water withdrawal and return devices and for withdrawal needs – including publicly supplied, industrial self-supplied, rural irrigation and power plant cooling – and many instream needs such as recreational boating, water recreation, fish and wildlife and visual and cultural needs.

Potable water treatment facilities are used for almost all publicly supplied water needs in the Region. Public health standards serve as the primary criteria for their use.

Meeting water quality standards is the primary criterion for use of physical, chemical and biological waste water control facilities. It is assumed that secondary waste treatment plants at the 85 percent level will be in use in almost all communities by 1980 and at the 90 percent level in almost all communities by 2020. Other needs that are also aided by these devices include publicly supplied, industrial self-supplied and rural water needs and water recreation, fish and wildlife and visual and cultural needs.

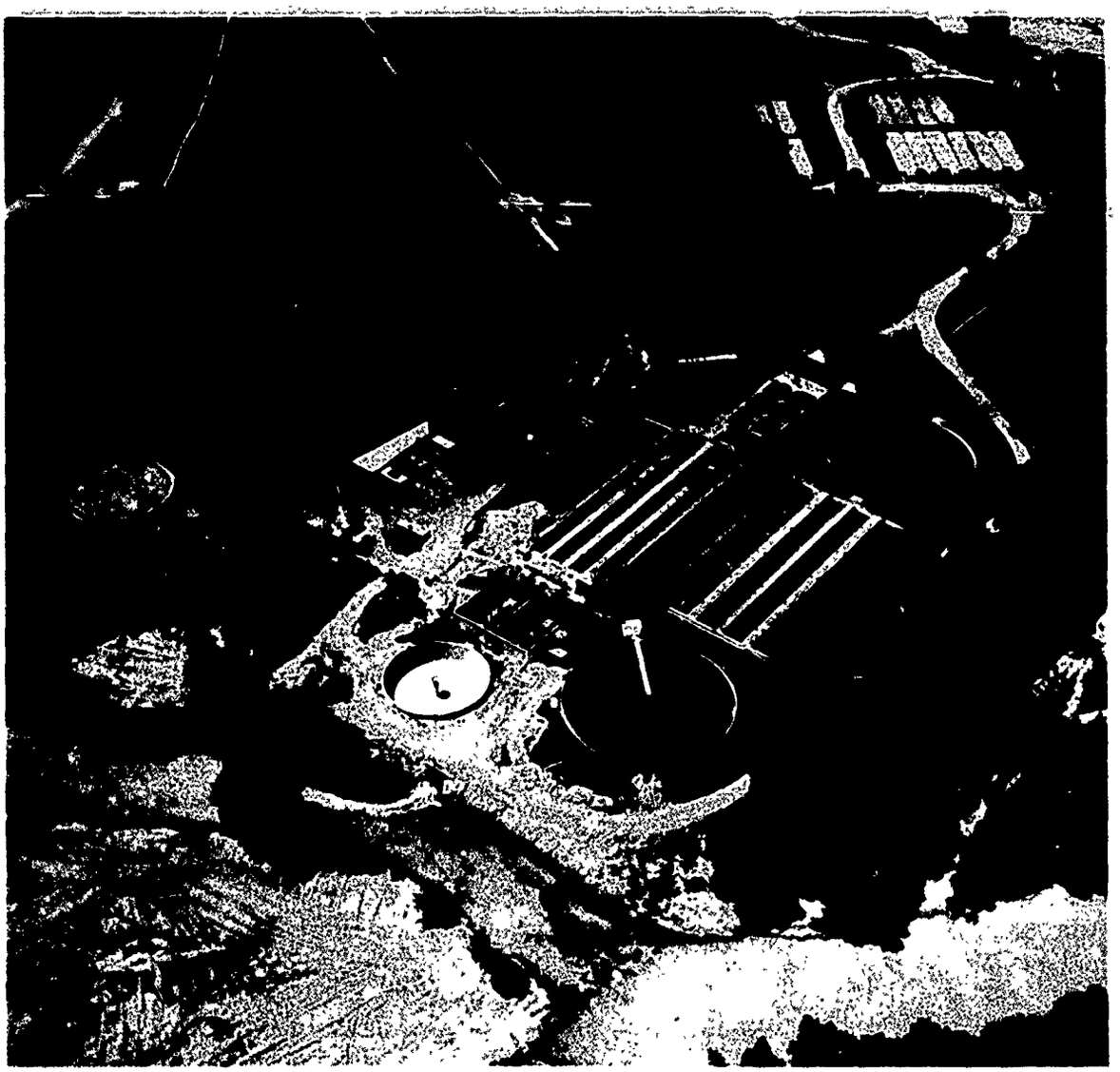
Advanced waste treatment plants, though expensive at this time, will be used along with low flow augmentation near the urban centers of the Region.

Legal limits on what can be dumped into public waters will be used with all of these various types of devices.

Septic tanks primarily occur in rural systems and controls of them are acquired through local legal requirements on the condition and type of septic tanks in use.

Facilities considered for controlling water temperatures consist most often of cooling towers and ponds.

Generally the use of cooling towers as power plant cooling facilities increases as greater emphasis is placed upon Environmental Quality in an Area. Regional Development may require cooling towers if this objective is to be achieved through water recreation and similar environmentally related needs. Where National Income is emphasized, cooling towers may have to be used to meet water quality standards.



Throughout the Region, water quality control facilities, such as this waste treatment plant at Leominster, Massachusetts, will have to be expanded to meet the rapidly increasing needs for water quality maintenance. (Department of the Army, New England Division, Corps of Engineers).

The technology of water quality control is a relatively new one. The first water treatment plant in the United States was completed in 1893 at Lawrence, Massachusetts and disinfection by chlorination was first introduced at Chicago in 1908. The quality control of wastewaters began even later and temperature control emerged only in the last two decades. Even so the available technology is advancing well ahead of its general application.

The most developed and widely applied portion of the water quality control technology is that applied to the supply of municipal and industrial water. This is an adequate and well applied technology that is nevertheless changing due to problems posed by new contaminants identified in water. Improvements are likely to occur soon in the ability to remove odors, tastes and colors at lower costs, to disinfect, especially viral substances, and to control dissolved, low level toxicants and nutrients. Further in the future, additional improvements in the chemical quality and in the control of radioactive substances are likely. The environmental impact of quality control facilities for water supply lies mostly in their value to public health. The plants themselves have environmental impacts in their immediate location.

To the well established primary and secondary (biologic) treatment methods an array of new add-on techniques are now becoming available usually grouped under the name of tertiary or advanced waste treatment. In addition, physical/chemical treatment has become practical entirely replacing the biological treatment phases. Also rediscovered has been landspreading of treated effluent, with subsequent recovery of water and a crop nurtured by the phosphates and nitrates in the effluent.

Improved sludge disposal by land spreading and by incineration is available and further improvements in the cost effectiveness of all parts of wastewater treatment is likely.

The environmental effects of the present and especially of the emerging technology should be profound. The recovery of high grade water and of some of the constituents of waste water as useful products is likely to have greater impact on the field of water resources development than all other technologic change now emerging for the near and mid-range future. The ecological impact is likely to be large, widespread, and positive while the visual impact will be site-specific and greatly influenced for good or bad by facility design. The social effect is likely to be significant, and both good and bad. There will be a high economic cost for these devices but the improved streams can be a great step towards better social amenities and the economic well being of people.

Concern for water temperature is relatively recent and has been brought about by an enormous increase in thermal electric power plants. The technology to cope with this problem in the form of cooling towers or ponds, has been available for some time from power plants designed in arid regions. This technology is presently expensive both monetarily and environmentally. Cooling towers and ponds generally reduce the level of water intake and the temperature rise in waters receiving the returns but at a cost of increased evaporation (water consumption) and increased energy used in the cooling process. The environmental effects range from improvements due to less effluent heating to damages due to fog and ice production and the visual impact of such structures as large cooling towers. Technological change in cooling systems is not likely to occur rapidly as the laws of thermo-dynamics limit change to small improvements. More promising are

future developments in the field of power generation in greatly reducing the use of steam or without a steam cycle. These potential new sources of energy include fuel cells, nuclear fusion, and fluid-dynamic converters.

The control and treatment of contaminated runoff such as mine drainage or street runoff is becoming feasible with emerging treatment and conveyance technology. This area of waste water control appears to be a fertile field for research and experimentation. Sanitary and storm sewers are presently separated in new construction but separation in existing towns is extremely expensive. Some doubt is emerging that separation of storm and sanitary sewers is necessary or even desirable if both must be treated.

Water quality control facilities are needed under all objectives but are used at their highest level under the Environmental Quality objective.

PUMPED STORAGE

Pumped storage devices are used to fulfill the hydroelectric power portion of peak generation needs in the NAR Region. These devices are used to supply peak power because of their ability to be quickly brought to full output for short periods of use.

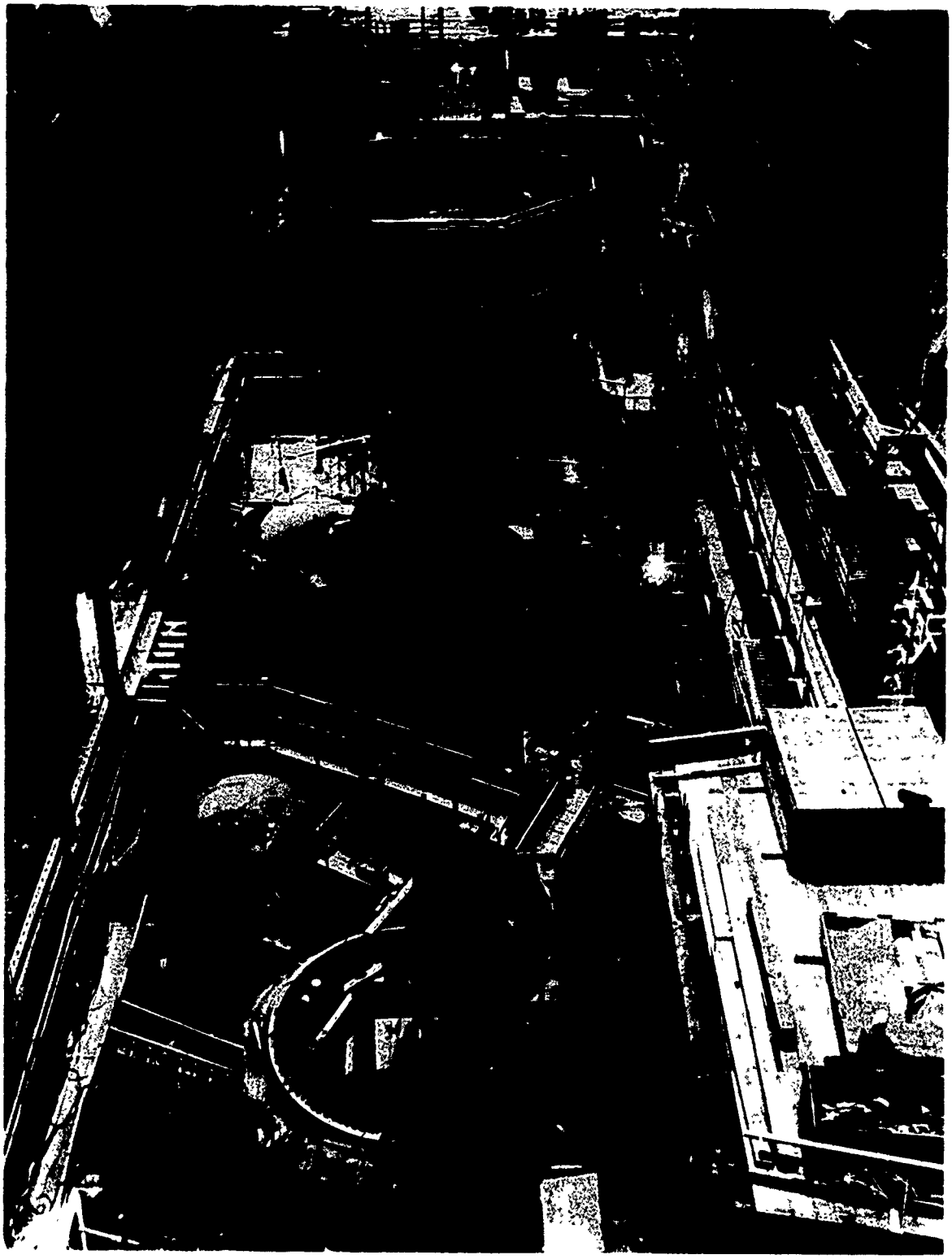
The need for peak power pumped storage devices is fairly well set as a proportion of total electric capacity (about 10 percent of the total). While peak power needs are distributed throughout the Region in relation to total power needs the availability of sites is the primary criterion for their use in each Area. Fairly steep terrain is required.

Technologic advances in underground construction methods and incremental improvements in reversible pump-turbine design are likely to make this power source increasingly responsive in meeting future power needs.

The environmental effect of pumped storage installations will vary greatly from facility to facility, based on site condition and design. Underground installations are likely to have the least impact on the environment. Ecologic problems are mostly confined to the intake structures and fluctuating pools.

Pumped storage can be expected to be used under all objectives. This device will be used with greater approval under the Regional Development and National Income objectives than under the Environmental Quality objective. Under that objective site conditions will bear most heavily on the decision to install pump storage generating facilities.

Adjustments can be made in the use of this device for the Environmental Quality objective. This means carefully locating each project away from areas of high environmental quality, locating it underground or utilizing landscaping and other screening techniques.



Scheduled for 1972 completion, this pumped storage project at Northfield Mountain, Massachusetts, will have a capacity of 846,000 kilowatts. This 1971 view shows the turbines in the powerhouse that is 700 feet underground. Connecticut River water will power the project. (Northeast Utilities Service Co.).

DESALTING FACILITIES

Desalting facilities in the NAR will be useful in the coastal areas probably in combination with electric power plants. The main problems with this device are its high cost, the large size of the installation and the disposal of the hot brine produced as a by-product.

Desalting processes in commercial use are of three general kinds: distillation processes, including multi-stage flash plants, vertical-tube evaporators, and vapor compression processes used in combination with other variations of distillation; membrane processes, including electrodialysis and reverse osmosis; and freezing processes. Desalting technology is just emerging as a practical alternative in water development. Cost reduction and reduction of waste products are the major goals. Significant improvements can be expected over the next 10 to 20 years. However, costs will continue to be relatively high, although competitive in some Areas, and the amount of hot brine discharged is not likely to be less than one half of the fresh water produced by the end of the 20 year period.

Environmental effects of desalting facilities are likely to be significant. These facilities are industrial installations with power sources, heat emissions and brine waste production. When combined with nuclear power plants — this is the most likely economic configuration for the future — they have all the environmental siting problems of large power plants. By themselves the visual and cultural impact at the site may be low to moderate while the ecologic impact of the brine discharge may be severe. Design features at specific sites may mitigate many of the detrimental effects. The use of desalting facilities may be applicable under all objectives.

MONITORING FACILITIES

The various types of monitoring facilities — fixed or mobile, automatic or manual — are an increasingly important device in the fulfillment of water quality maintenance and health needs in the NAR. There is a great lack of monitoring of temperature, chemical and biological pollutants throughout the Region.

The use of monitoring facilities essential to all water developments will probably not depend upon differences in objectives, but primarily upon the size of the basin and the types of pollutants likely to be found.

Meeting the Region's important water quality maintenance needs will require extensive and detailed information on water pollution. Shown above is the floating laboratory "Clean Water's" that is used for on the spot monitoring of pollution. (Environmental Protection Agency).

The technology of continuous monitoring of water and related land resources is young and rapidly changing. Only in the 1940's did transmission of water quantity and temperature information become generally practical. Since then the technology of continuous measuring has rapidly improved to include: numerous water quality parameters; remote displays; and computerized networks that collect, evaluate and display water resources data at preset time intervals. Near future technology can be expected to include monitoring of additional water quality parameters and remote sensing from satellites of many water and land resource parameters.

The environmental impacts of the installation of monitoring networks should be very small as the monitoring equipment is small. The largest impact would be visual from radio aerials, access roads and monitoring stations in remote areas.

FLOOD PLAIN MANAGEMENT

This device consists of a collection of land management tools that include mapping, zoning, land purchases, insurance, taxes, landscaping, leasing, flood proofing, emergency warning systems and other procedures. These tools are under local, state and Federal jurisdiction and when recommended for use in the NAR they can be applied in various combinations to assist in meeting upstream and downstream flood damage reduction needs, and also visual and cultural, water recreation and fish and wildlife needs.

To achieve upstream flood damage reduction under the Environmental Quality objective, only flood plain management is used. Flood plain management is used under the National Income and Regional Development objectives to protect urban and urban amenity related lands not protected by structural measures.

Achievement of mainstream flood damage reduction through flood plain management in the Region is dependent upon various characteristics of each site, including: topography, width of flood plain, damage density, stage of development, local governmental attitudes, institutional arrangements and visual and cultural values. Flood plain management for mainstreams is recommended in all Areas and an effectiveness factor for flood plain management in each Area was developed to estimate the amount of damage reduction achievable.

The use of flood plain management is higher under the Environmental Quality objective while more reliance on structural devices is assumed under the National Income and Regional Development objectives.

The technology of flood proofing measures is well developed and changes are apt to be only incremental. The land use control side of flood plain management is a problem of institutional change and here the techniques to efficiently effect such change are rudimentary at best.

Education of officials, managers and citizens as to the real costs of flood plain occupancy appears to be the most hopeful approach toward institutional changes to improve flood plain management.

The environmental effects of flood plain management are likely to be positive through improvement of visual qualities, ecological stability and social benefits such as open spaces and recreation areas. Simultaneously, there may be detrimental effects due to the disruption of existing development.

Flood plain management appears to be the only technology capable of reducing flood damages beyond the limits imposed for many reasons on flood control structures.

LOCAL FLOOD PROTECTION

Channeling, levees, small holding reservoirs, bypass channels and drainage systems are several of the devices included in local flood protection projects. These devices are used in different combinations alone or in combination with reservoirs and flood plain management to fulfill upstream and mainstream flood damage reduction needs. These devices are also used to fulfill tidal and hurricane flood damage reduction needs.

Local flood protection for flood damage reduction depends upon a consideration of existing, authorized, planned and projects under study; evaluation of physical site potential for reduction of damages, and a consideration of the acceptability of protection devices as opposed to management devices.

Agencies responsible for structural measures were consulted to determine which projects are considered to have positive benefit/cost ratios and local acceptability and, thus, to be

This "morning glory" intake conveys flood waters to an underground conduit at Worcester, Massachusetts. (Department of the Army, New England Division, Corps of Engineers).

part of their respective programs. The probable order of implementation was estimated so that damage reductions could be determined for benchmark years.

The projects included were those felt to be feasible and acceptable to local interests. Increasing reliance was put on flood plain management to meet remaining needs.

The technology used to protect flood hazard areas by local works is an old one. There is little likelihood of improvements other than the use of new materials or construction techniques. Local flood protection structures are site specific and improvements can be made by designs appropriate to the location and its specific problems.

Environmental effects of local flood protection works are significant. Visual and cultural effects are usually moderate to high and adverse as levees, channels and their accompanying structures are long, very visible and often interfere with movement of people and vehicles. Ecologic effects are likely to exist where channelization significantly alters the flow and the shorelines of a stream.

Local flood protection works for existing damageable properties are compatible with all objectives. For new areas not yet developed, structures are usually only compatible with a Regional Development objective.

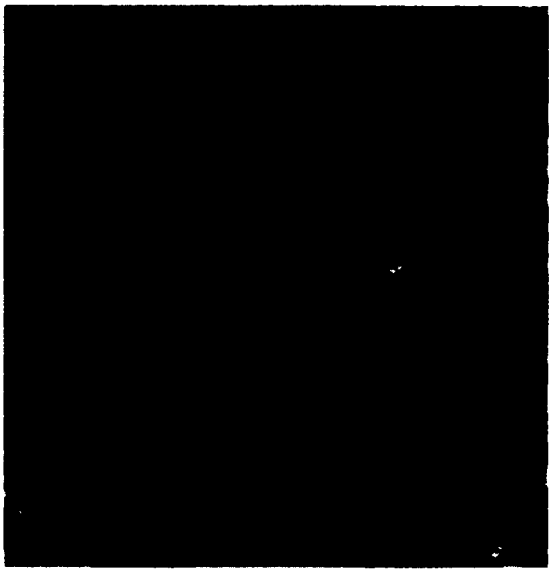
WATERSHED MANAGEMENT

A wide variety of devices is used for watershed management to help meet the needs of fish and wildlife, visual and cultural, upstream flood damage reduction and drainage control. The use of these devices also aids in decreasing sedimentation in streams and rivers and aids in the management of wildlife. Watershed management is directed towards the reduction of overland water flow and runoff and the increasing of water interception, infiltration and soil-moisture storage. The specific devices include small, flood water detention facilities and various land management practices. These management practices include crop rotation, terracing, contour strip cropping, selective planting of cover crops, wildlife habitat development, selective timber harvest and logging, reforestation and control of grazing, fire and insects.

The use of watershed management alone for upstream flood damage reduction occurs entirely within the Environmental Quality objective. This device is used for all drainage control needs as a complement to drainage practices.

Several portions of the visual and cultural need are partially filled by the use of watershed management including protection of quality and composite landscapes and development of quality landscapes and clean water.

While the technology for this type of management is rather [illegible]s well established and rather stable.



This Warren County, N.J., farmland provides a graphic example of the agricultural conservation practices of strip cropping and contour plowing. (Department of Agriculture, Soil Conservation Service).

Environmental effects of watershed management are considered generally beneficial. In specific areas, however, ecologic effects would be detrimental depending on the objective of the management project and the part the area plays in the region's ecology. Watershed management is applicable under all objectives with special emphasis under an Environmental Quality objective.

EROSION PROTECTION

Erosion control and water recreation needs can be partially fulfilled through the use of erosion protection devices. Stream and river sedimentation is also decreased by the use of these devices. Erosion protection is a combination of steps to reduce an otherwise natural process, the movement of soil by water. It is also part of an effort to lessen the increase of erosion due to man's impact on his environment.

Land treatment practices can be divided into three categories. Vegetation is used, such as grasses, shrubs, and trees, to cushion the impact of rain and retard runoff. Mechanical practices, such as contouring and terracing, are used to reduce the length of slope and the velocity of overland flow. Structures are used that range from small grade stabilization structures to large gully stabilization structures with detention features.

Settling basins are also used to capture the sediment from streamflow. A combination of vegetation and physical devices, such as contour strip-cropping, can be highly effective.

Shore protection, both coastal and riverine, is another aspect of erosion protection. Solutions are generally limited by very high cost, and complicated by the patchwork of private and public ownership of the shoreline. They include flood plain management practices; protection of wave impact areas by means of bars and breakwaters, groins, bulkheads and sea walls; and the preservation of inland dunes.

The technology for erosion protection on land is well established and stable. For shore protection the technology is changing and research results may well bring significant improvements.

Environmental effects of erosion protection are generally beneficial except near structures where site-specific conditions may cause negative visual, cultural and ecological impacts.

Presently there are no differences in the level of use or types of these devices for different objectives. Differences are achieved by the users of these devices at the individual sites.

DRAINAGE PRACTICES

The results of land drainage devices vary from the mechanical transference of surface water and groundwater out of an area, to the achievement of better water absorption by improvements in soils. Drainage measures include tile, concrete, or plastic pipe installed beneath the surface; open drainage ditches, large steep-sided structures for collection water within a field; and pumping facilities, for removing excess surface and ground water from lowlands where there is no gravity outlet. Alternative devices that, at least to some extent, achieve better water absorption, include: channel relocation, selective clearing and snagging, one-side channel excavation, notched ledges, stacking and planting of spoil banks.

Drainage is practiced on wetlands, croplands and forest lands. The devices used for each type of drainage vary greatly in size and means of application although the control of water level is the objective in each case.

This is a well established technology. With the exception of possible improvement in the techniques of installing drainage devices few changes in the technology of drainage are expected.

Environmental effects of drainage are always very significant. Drainage changes the visual, cultural and above all ecological character of the area so treated. The impact varies most with the type of land involved. Impacts are least if land to be drained is cropland and the drainage is for the purpose of increased crop production. Impact is greatest if the area drained is biologically productive wetland.

Some drainage is likely under all objectives. Most can be expected under a Regional Development objective. Least use of this device will occur under the Environmental Quality objective, especially as this device relates to wetlands.

WATERWAY MANAGEMENT

Many devices are listed for navigation needs that include commercial navigation and recreational boating. Several navigation devices can be substituted for one another.

Port facility requirements are dependent upon the mode of land transportation, the vessels used and the amount and type of commodities handled. Cargo diversion to other ports shifts needs for navigation facilities. Modification of port facilities may be required if the method of commodity delivery is modified such as by lightering, construction of off-loading facilities or use of pipelines. Significant changes in the type of commodities handled also affect navigation facilities.

Variations of navigation devices occur under the three objectives. For Regional Development the maximum development of the harbors and waterways would be achieved. For Environmental Quality improvement of existing waterways would be minimized. However, consideration should be given to cargo diversion from an Environmental Quality Area or changing the method of delivery. Lightering or off-loading facilities may help to achieve the Environmental Quality objective. Achievement of the National Income objective would emphasize efficiency of commodity movements. It requires detailed study of costs and benefits which are beyond the scope of this Study. However, the development programs for National Income would generally not be as extensive as for Regional Development but greater than those for Environmental Quality.

This view of Scituate, Massachusetts Harbor is an excellent example of the large and growing recreational boating needs in the NAR. (Department of the Army, New England Division, Corps of Engineers).

It should be noted that the range of development programs given in Appendix K, Navigation, is considered valid only under present conditions. If a deep water port is constructed, the programs would have to be reevaluated.

Recreational boating needs require marinas that are assumed to be supplied by private sources in this Study. The commercial navigation devices also help achieve recreational boating needs especially channel improvements, lock rehabilitation, obstruction removal, breakwaters and jetties and navigation aids.

Most technology for waterway management is well established, stable and mature. Changes can be expected due to the changes in the technology of water transportation and recreational boating. The trend towards larger and deeper draft ships has materially changed the need for channel improvements, and has led to the advent of off-loading facilities, the development of cargo containers has changed the arrangements of piers and other port structures. The number and wide range of sizes and pleasure craft have changed the size and increased the number of small boat harbors and small boat docking and servicing facilities. Future changes can be expected to

follow the trends established in the last decade.

The environmental impacts of waterways management facilities are likely to be significant in magnitude and both beneficial and detrimental. Detrimental impacts may include among others the preemption of shoreland for port facilities, congestion, disturbance of ecologic communities and the danger of pollution from leaks or spills. Beneficial impacts include recreation, and the visual attractiveness of a busy harbor.

Some waterway management is compatible with each objective. The emphasis on specific parts will vary greatly with the objective and with site conditions.

LAND CONTROLS

Any means of regulating the use of land can be considered a land control. Six separate means of land control are considered in this Study to help fulfill visual and cultural, fish and wildlife and water recreation needs. These means of control – purchase, purchase lease, easements, deed restrictions, tax incentive subsidy, and zoning – can be used to regulate beaches, river fronts, wild areas, parks, and access for all types of water use including swimming, fishing, hunting, boating and nature study.

Use of some devices varies according to objectives for the visual and cultural need. Where complete control is desired purchase is best although the cost is also highest. This device is used under the Environmental Quality objective to assure the greatest amount of protection. When the cost is too high or only access or restrictions of use are desired then leases, easements or deed restrictions are recommended. Zoning is used primarily for National Income and Regional Development objectives since it is least expensive. This device has not always been effective because of the lack of consistency in its application and the ease with which zoning regulations can be changed.

Tax incentive subsidies are inexpensive and also recommended for the National Income and Regional Development objectives, but presently are not in common use. This device can be used to motivate special uses such as agriculture or encourage installation of special devices such as those for pollution control.

Many needs which are filled by water resources depend on land control techniques that are known. Procedures are still undeveloped for efficient implementation of the institutional changes needed to implement these land controls. Progress can be expected through better understanding of the problems and greater pressure for conflict resolution. Progress, however, is likely to be slow.

Land controls have significant impacts on the environment that are wide ranging and affect visual, cultural and ecologic components of the environment.

Land controls are useful under all objectives but most important to the achievement of Environmental Quality.

Camping is a popular activity at Whitney Point Lake in the Upper Susquehanna River Basin in New York's Southern Tier. It is vital at such sites to have land facilities for water recreation and access to the water for sport fishing and nature study. (Department of the Army, Baltimore District, Corps of Engineers).

LAND FACILITIES

The use of water resources for water recreation, fish and wildlife and visual and cultural needs requires physical facilities at the point of use or access. These facilities include camping, beaches and picnic sites for water recreation developments; roads, railroads, or airports for transportation to the facilities, parking and trails; and site sanitation and utilities.

The quantities of facilities for fulfilling water recreation needs are based on case studies and censuses of daily and seasonal use. These level of use figures for different types of facilities and recreation activities were averaged by NAR subregions and vary by objective High density use of facilities is expected for Regional Development which requires the same investment level as for the National Income objective where facilities do not have so high a level of use.

The level of use under the Environmental Quality objective is lower but the investment level is raised to achieve a higher quality experience for the recreationists.

No differences occur in the use of facilities for other than the water recreation need.

The technology of constructing facilities, such as access, parking and recreation areas is well established.

Land facilities affect the environment generally in a geographically limited area. As part of other devices they are compatible generally with all objectives; their site-specific design will govern their impact on the Environmental Quality objective.

Land facilities and land controls are essential parts of programs for all objectives.

BIOLOGICAL MANAGEMENT

Devices for fisheries and wildlife management help fulfill the needs of fish and wildlife while the insect control device helps fulfill the health needs. Management devices for fish and wildlife are similar in their approach although different in actual practice. Fish and wildlife can be managed by limiting harvests, managing habitats and sometimes by stocking. Habitat management is either the rebuilding or maintenance of the environment within which the animal lives to provide optimal reproduction, migration and living conditions.

Fish require proper water temperatures, depths, currents and quality and prosper best when there is plentiful food, water area and general living conditions such as shading. Wildlife, whether birds or big game, has requirements for altitude, temperature range, cover, food and migration routes. Management practices can help achieve proper conditions for fish and wildlife. The degree of aid generally depends on the size of the range of the animal and the sensitivity of the animal to changes in the environment.

The use of fishways is specifically mentioned in this Study as a device because it is particularly the key to the retention and achievement of the anadromous fish runs that are becoming increasingly scarce in the Region.

Insect control is used to help eliminate water associated insects that transmit diseases to man. Control programs exist for mosquitoes, blackflies, greenhead flies and midges. Programs for ticks do not presently exist.

Fish and wildlife management is fairly old as private forests and rivers have been managed for sporting purposes for many years. Strict application of scientific knowledge, however, has only come about since the turn of the century. Improvements are generally slow in this field because of the research time that is required and also because of public attitudes that must often be changed before new procedures will be accepted. Typical of such attitudes is the animosity shown towards the selective use of high temperature effluents for increasing the productivity of cold water lakes and streams.

New surveillance techniques using remote controlled devices and inter-disciplinary research groups are two research approaches that should produce the greatest insights into management techniques.

Public attitudes have been changed by the recent emphasis upon environmental problems. This emphasis, however, has concentrated on preservation rather than on how to determine and achieve the best use.

RESEARCH AND EDUCATION

Research and Education may not directly affect water and related land uses. They are nevertheless very important activities for the long range resolution of resource use conflicts. The results of research affect the entire range of water resources development technology and education furthers the implementation of any plan and affects the types of demands people place on water. Research and Education are a part of any plan under any objective.

WATER DEMAND AND ALLOCATION CHANGES

Changes in demand are the ultimate and in the very long range only permanent solutions to some water demand problems. In spite of this, past experiences have not been reassuring that large advances in demand reduction or reallocation are achievabie either now or in the near future. Demand reduction through changes in technological processes in heavy water using industries have already had some impact on demands and can be expected to produce significant improvements in the future. Tandem use of water -- the use of highgrade water for some activity and its degraded effluents for reuse in an activity that can use lower grade water -- is beginning to be of importance.

Planning for the re-use of wastewaters after treatment is also progressing and a few plants are in operation for municipal and industrial supplies. The near and mid-range future will see an increase in the use and improvement of water re-use technology.

The change of demand through pricing or rationing has met with little and usually only temporary success to date. Techniques to induce change in peoples' views on water use and to induce change in institutional arrangements controlling water demand are generally iacking and the near future at least does not appear bright. Restriction of demand growth through population and economic development limits are techniques of uncertain acceptability.

Environmental impacts of demand reduction would generally be zero on the natural environment. Their cultural impacts on society would be significant and in the long run would force basic changes in life style and resources consumption.

Demand constraints in the short run are likely to be in conflict with Regional Development objectives while significantly complementing the Environmental Quality objective. In the long run they are likely to be the most important steps towards the solution of water resources problems and compatible with all objectives.

PROJECT OPERATION CHANGES

Changes in the management of existing water resources projects such as lifting of restrictions of recreation on water supply reservoirs, the addition of a new purpose to a project, or the reallocation of project outputs, are functions of institutional and policy changes. Procedures exist to accomplish such changes but they are slow and improvements in these procedures may develop slowly.

Project operation changes, depending on their magnitude, will have a wide range of environmental effects ranging from none to significant. Project operation changes are applicable under all objectives.

CHAPTER 8

A PROGRAM FOR THE REGION

The mixed objective Regional Program for the North Atlantic Region is a summary of the 21 Area Programs presented in Annex 1. This Chapter contains a description of the more important assumptions on which the NAR Program is based; a discussion of the Area Programs; material derived from the Area Programs that forms the basis for Study conclusions; the Summary Regional Program; and a discussion of steps needed for implementing the Regional Program.

ASSUMPTIONS

All plans are based on sets of conditions, one set for describing what exists and how things function at the starting point and other sets that define the conditions at future dates. Some of these conditions are accepted as facts, such as the highest flood experienced at some point on a river; most, however, are assumptions to describe the system which is being planned for or to describe actions or relations of various planning elements such as needs, devices, benefits and costs. Many assumptions have been made throughout this Report and in the appendices. For clarity and understanding of the programs, however, the most significant assumptions are summarized here. They are described in two groups, those assumptions that apply to the Study as a whole and those that apply to specific Areas or groups of Areas.

General Assumptions

1. Population will continue to grow at a slow rate. For the National Income and Regional Development objectives this rate is 1.3 percent per year (U. S. Census Bureau Population Series C, 1965); for the Environmental Quality objective the assumed growth rate is 1.0 percent (Census series D).

2. Productivity will grow at a slow rate as in the recent past. An annual growth in employee productivity of 3.0 percent is accepted for the National Income and Environmental Quality objective and 3.2 percent for the Regional Development objective.

3. Urbanization will continue to be a major factor controlling the Region's growth pattern.

4. The mixture of products required in the NAR is the same as that in the Nation as a whole and is the same for all objectives.

5. Municipal water use will continue to increase, but at a much slower rate.

6. Reductions are projected in some industrial water uses because of expected technological changes. Reductions are projected for the Food, Textile, Petroleum Refining, Primary Metals, Paper and Chemical industries.

7. Institutions existing now can be modified to accomplish the programs developed and new institutions can be formed.

8. The National resolve for a cleaner environment will continue and budgetary constraints for this purpose will be less than at present.

Specific Assumptions

1. Existing conditions generally are those that existed in the 1964-65 period. For the water development portion of the program, however, that is based on the computer supply model, the following reservoirs that were under construction or in the final design process were assumed to be part of existing conditions:

Area 15:	Tocks Island
	Beltzville Lake
Area 17:	Raystown Lake
Area 21:	Gathright Lake

The failure of any one of these projects to be completed would increase storage requirements in the respective Areas or in neighboring Areas to replace the lost storage.

2. Risk levels of 0.01 shortage index or approximately 7 day low flow with a recurrence interval of 50 years were used to determine water supply capabilities, storage requirements and instream water availability. In specific instances where local conditions might require more stringent criteria as developed in detailed studies, additional storage or importation would be required.

3. All water was considered available for any one use in the single purpose analyses of the appendices. In the Area Programs, however, all withdrawal needs were considered simultaneously through the use of the supply model. In Areas 1 through 16 it was assumed that 0.2 cubic feet per second per square mile (csm) of drainage area must be maintained after all withdrawals. In Areas 17 through 21 the figure of 0.1 csm was used. This is based on the minimum requirements of fish and wildlife interests which are generally the largest of instream minimum flow requirements. Significant local changes from these assumptions would increase or decrease available water in any location or change storage or importation requirements. Effects of these assumption changes would be most significant on the large rivers.

4. Area or sub-area outflow limitations were assumed equal to the minimums described in the preceding paragraph except that: minimum outflows from sub-area 12b (Hudson at Poughkeepsie) be 2000 cfs which is equal to the present day minimum flow; minimum outflow from sub-area 15a (Delaware at Montague) be 1750 cfs as prescribed by the Supreme Court decree; and that outflow from sub-area 15b (Delaware at Trenton) be 3000 cfs as desired by the Delaware River Basin Commission.

5. That no reservoirs be permitted in the Adirondack Forest Preserve in accordance with New York State statutes.

AREA PROGRAMS

Plan formulation proceeded from the approval of alternative planning elements to the selection among them for Programs in the 21 Areas. The first selection was made among the alternative objectives for each Area. This selection was the work of state members of the Plan Formulation Work Group and was reviewed by members of the Coordinating Committee.

The resulting mixes of objectives are listed in Table 35 for each Area; their implied relative values are shown in the bar graph of Figure 29. The bar graph shows several Regional patterns formed by the chosen objectives. Of the three objectives, Environmental Quality has been emphasized to the greatest extent throughout the Region, followed by Regional Development and then National Income. Areas 4, 5, 11, 12, 15, 18 and 20 have had Environmental Quality emphasized to a larger extent while in Areas 6, 10, 19 and 21 the Environmental Quality objective has been emphasized the least.

Regional Development has been less evenly emphasized throughout the Region than Environmental Quality. Regional Development has been greatly emphasized in Areas 1, 7, 10 and 21 while less emphasized in Areas 8, 11, 12, 17 and 18 and de-emphasized in Areas 2, 3, 4, 6, 13 and 20.

National Income has been emphasized throughout the Region in the most irregular pattern of the three objectives. National Income has been emphasized to the largest extent in Areas 6 and 19 and to the least extent in Areas 1, 5, 7, 12, 18 and 21.

Environmental Quality has been emphasized to the largest extent in those Areas which have two characteristics. First, these Areas have high quality natural resources that can be used to fulfill water recreation, visual and cultural and fish and wildlife needs. Second, the Areas are close to large population centers so that large numbers of travelers and vacationers will be taking advantage of these resources in the future. This combination of resources and needs calls for care in planning for these Areas.

TABLE 35
MIXED OBJECTIVE
FOR NAR AREAS

Area	Mixed Objective
1.	RD and EQ
2.	EQ and NI
3.	EQ and NI
4.	(a) EQ with some NI (b) NI and EQ
5.	EQ with some RD
6.	NI with some EQ
7.	(a) EQ with some RD (b) RD with some EQ
8.	EQ and RD New Hampshire - EQ with some NI
9.	(a) EQ with some NI (b) RD with some EQ
10.	(a) NI and RD with some EQ (b) EQ and RD
11.	Vermont - EQ with some RD New York - RD Adirondack Forest Preserve - EQ
12.	RD with EQ Adirondack Forest Preserve - EQ
13.	NI and EQ
14.	New York - RD with EQ New Jersey - EQ upstream NI downstream
15.	New York - RD with EQ Pennsylvania - EQ, RD, and NI New Jersey - (portions of b) EQ (portions of d) NI, EQ, and RD Delaware - (portions of d) EQ
16.	(a) NI with some EQ and RD (b) EQ with some RD and NI
17.	New York - RD and EQ Maryland - some EQ with NI Pennsylvania - RD and EQ
18.	Maryland - RD and EQ Delaware - EQ Virginia - RD, EQ for Barrier Islands
19.	NI with some EQ and RD Pennsylvania - EQ with some RD
20.	EQ with some NI
21.	RD with some EQ

IMPLIED RELATIVE VALUES OF MIXED OBJECTIVES FOR NAR AREAS

AREA	NAME	OBJECTIVE 1/ RD NI EQ
1.	St John River Basin	
2.	Penobscot River Basin	
3.	Kennebec River Basin	
4.	Androscoggin River Basin	
5.	Maine Coastal Basins	
6.	Southern Me. and N.H. Coastal N.H.	
7.	Merrimack River Basin	
8.	Connecticut River Basin	
9.	Southeastern New England	
10.	Thames and Housatonic River Basins	
11.	Lake Champlain and St. Lawrence R.	
12.	Hudson River Basin	
13.	Southeastern N.Y. Metropolitan Area	
14.	Northern New Jersey	
15.	Delaware River Basin	
16.	Coastal New Jersey	
17.	Susquehanna River Basin	
18.	Chesapeake Bay and Delmarva Peninsula	
19.	Potomac River Basin	
20.	York and Rappahannock	
21.	James River Basin	

1/ Line represents percent of total of each objective as follows:

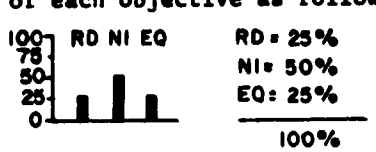


Figure 29

Regional Development is emphasized primarily in Areas of high unemployment and/or low per capita income. In some Areas of this type (2, 3, 4 and 5) Regional Development is not emphasized as an objective; rather it is expected that the objective will be achieved by emphasis on Environmental Quality and the resulting regional income flows from recreationalists. Area 20 is expected to be able to achieve adequate economic levels through investments to meet National Income objective levels, as are Areas 6 and 19.

Five Areas have been given equal emphasis for two objectives – Areas 1, 2, 3, 7 and 13 All of these have Environmental Quality included as one of the objectives. Three Areas – 1, 7 and 10 – are expected to achieve Regional Development through the aid of the Environmental Quality portion of the objective mixes.

Once there was agreement on the mixed objectives of each Area, selection of alternative needs and devices proceeded according to the description in Chapter 5. The quantity of each need and device was agreed upon which the Plan Formulation Work Group felt would best achieve the mixed objective of each Area. The "mixed objective" Area Programs resulting from this process are presented in Annex 1 in numerical and descriptive forms.

Needs, devices and costs of each mixed objective Area Program are presented in 21 sets of Tables in Annex 1, one set for every Area. Descriptions of each Area Program's objectives, needs, devices, costs and benefits appear along with each set of tables. These descriptions include the reason for having selected a specific alternative and the comparative sizes, growth rates and per capita sizes when appropriate. The methods used in deriving these Area Program descriptions are given in detail in Chapter 2 of Annex 1.

Alternative programs for each Area were also selected during the plan formulation process and descriptions of these alternatives accompany each Area Program. These descriptions show the changes that would occur in the mixed objective program if one of the objectives were emphasized alone in an Area. Differences between the alternative planning elements and the alternative objective programs are not very large in the present Study.

In addition to agreement on alternatives, the Plan Formulation process developed two more products: a better understanding of the benefits and costs that would result from choosing any of the alternatives and of the limitations placed on the selection of objectives for emphasis in each of the Areas.

The total benefits and costs of the alternative programs for the Areas can be summed to obtain estimates of these totals for the Region, although these are not presented here. Such totals would provide somewhat rougher estimates than the totals presented for the recommended plan, since the latter have been subject to somewhat more analysis and adjustment than the estimates for alternative data. While the available information on alternative costs for each Area are presented in tables in Annex 1, available information on benefits for each of the alternative devices are described in Chapter 7 of the Report and in the benefits section of each Area Program in Annex 1.

During the Plan Formulation process, it became evident that there were limitations on the objectives that could reasonably be chosen for a number of Areas. These limitations on the objectives were felt to occur for ten Areas because of inadequacies or strengths of the various resources of these Areas. For these Areas, it was felt that certain objectives could not be reasonably considered as alternatives for primary emphasis or emphasis alone. It was felt that the eleven other Areas could have any combination of objectives emphasized in their Programs depending on the desires of the states, or local governmental bodies and the residents of the Area.

Table 36 shows the limitations on the objectives that became evident. Only Environmental Quality should receive emphasis in the Adirondack Forest Preserve of Areas 11 and 12. Environmental Quality should receive at least some emphasis in Areas 2, 3, 5, 11, 12, 13 and 17. This need for Environmental Quality occurs in most of these Areas because of the amount of environmental resources that are receiving increasing pressure from visitors and will need to be preserved and maintained. Area 13, on the other hand, has fewer resources and these need upgrading to provide for the very large population pressures exerted upon them. Environmental Quality should also receive emphasis around the recreational portions of Lake Sebago in Area 6 because of similar local population pressures on its resources.

Regional Development will probably be limited in its emphasis in Area 4 because of the present lack of access into the Area which makes such a plan difficult to achieve. Regional Development through water resources development should not be emphasized alone in Areas 10 and 13 because their presently high income level makes this objective unnecessary. The pockets of low income in Area 3, however, could receive Regional Development emphasis. Some attention should be given to Regional Development in Areas 11 and 17 because of the general need for raising levels of employment and per capita income.

National Income could not receive primary emphasis alone in Area 11 since it would not meet the Regional Development needs of the Area that include unemployment and low income. It is unlikely that any single objective should be emphasized alone in Area 15 because of the wide variety of problems, resources and needs in that Area.

BASIS FOR CONCLUSIONS

A selection of variables and data from the 21 Area Programs is now presented from which study conclusions will be drawn. This presentation will accomplish several of the purposes of the NAR Study – those purposes related to the identification of priorities for basin and project studies and to the identification of priorities for action within the Area development programs.

The variables selected are: key needs; important needs; large needs; large per capita needs; fast growing needs; key devices; important devices; large benefits; and large costs. These variables are defined and their use described in the "Regional Programs" section of Chapter 5.

TABLE 36
LIMITATIONS ON OBJECTIVES
OF NAR AREAS

Area	Limitation	Area	Limitation
1.	None	11.	RD should receive some attention; no primary emphasis upon NE alone; EQ alone in Adirondack Forest Preserve
2.	No objective emphasized alone and EQ should receive some attention	12.	EQ alone in Adirondack Forest Pre.
3.	EQ should receive some attention	13.	No primary emphasis on RD in Area as a whole except for small pockets; EQ desired at some level, but not alone
4.	Different objective mixes for all sub-areas; RD will probably be limited due to lack of access	14.	None
5.	EQ should receive some attention	15.	Unlikely that any single objective should be emphasized alone
6.	EQ should receive some emphasis around Lake Sebago	16.	None
7.	None	17.	Objective mix should differ by sub-area and by state due to diversity; EQ and RD should receive some minimal attention
8.	None		
9.	None	18.	None
10.	Different objective mixes for all sub-areas; no primary emphasis upon RD alone due to present high income.	19.	None
		20.	None
		21.	None

Key and important needs and devices are new terms (defined on page 118) and may prove difficult to understand. The terms represent in this Study the criteria by which certain needs and devices of an Area Program stand out as having greater impact than other needs and devices in the Area. The impact may be technological, economic, environmental, biological or social and does not necessarily depend upon the size or growth rate of the need or the quantity and timing of the device.

Impacts may be of four types. Important needs have a greater impact than other needs on achieving an Area's mixed objective. Important devices have a greater impact than other devices on fulfilling needs of an Area. Key needs have a greater impact than other needs on helping fulfill the needs of an Area and key devices have a greater impact than other devices on making devices successful in the Area. It would be these key and important needs and devices that should receive greater attention (priority) when budgets become smaller or larger.

Tables 37 and 38 indicate which needs are either key or important in each Area. Tables 39, 40 and 41 show the ranking of Areas by the sizes of their various needs; by their need sizes per capita; and by their need growth rates. Tables 42 and 43 indicate which devices are considered key or important in each Area. Table 44 shows which needs when fulfilled are likely to produce large benefits in each Area and Tables 45 and 46 rank devices by costs within each Area and rank Areas by costs for each device respectively. Areas are also ranked by the sizes of their costs per capita in Table 47.

The rankings are only for those needs and costs which are felt to have the greatest bearing on choosing priorities. The rankings are for all benchmark years (including the present for needs) so that the highest rank that a need or device achieves within any of those years is shown. In these rankings, it is assumed that the projects mentioned as existing under the assumptions set forth in Chapter 4 have been completed and their services available to the people of the Area in which they are located.

SUMMARY REGIONAL PROGRAM

Programs that evolve out of planning activities are agendas for action. This section summarizes the mixed objective Regional Program of the NAR Study including the needs and devices and their implications (benefits and costs). These planning elements of the Study fall into three distinct though related Programs for the Region that include: Water Management, Land Management and Environmental Management. These Program categories are used because the planning elements in each have one or more similar functions, financial arrangements, means of action and impacts upon resources.

Total Regional needs, devices and costs are presented in Tables 48 through 51 at the beginning of each of the three mixed objective Programs. The Regional patterns of each of these planning elements, including benefits, are then described for the 21 Areas using the data first presented in Tables 37 through 47. Numbers are used in place of names for the 21 Areas in these descriptions to simplify the presentation.

TABLE 37
KEY NEEDS IN EACH NAR AREA

		Publicly Supplied Water	Industrial Self-Supplied Water	Rural Water Supply	Irrigation Water	Power Plant Cooling	Hydroelectric Power Generation	Commercial Navigation	Recreational Boating	Water Recreation	Fish and Wildlife	Water Quality Maintenance	Flood Damage Reduction	Drainage Control	Erosion Control	Health	Visual and Cultural
1	ST. JOHN RIVER BASIN											X					X
2	PENOBSCOT RIVER BASIN											X					
3	KENNEBEC RIVER BASIN											X					
4	ANDROSCOGGIN RIVER BASIN											X					X
5	MAINE COASTAL BASINS											X					
6	SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE																
7	MERRIMACK RIVER BASIN											X					
8	CONNECTICUT RIVER BASIN											X					
9	SOUTHEASTERN NEW ENGLAND										X	X			X		
10	THAMES AND HOUSATONIC RIVER BASINS																
11	LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE																
12	HUDSON RIVER BASIN											X					
13	SOUTHEASTERN NEW YORK METROPOLITAN AREA	X										X					X
14	NORTHERN NEW JERSEY																X
15	DELAWARE RIVER BASIN								X			X					
16	COASTAL NEW JERSEY											X					
17	SUSQUEHANNA RIVER BASIN											X					
18	CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE											X					X
19	POTOMAC RIVER BASIN											X					X
20	RAPPAHANNOCK AND YORK RIVER BASINS																
21	JAMES RIVER BASIN											X					

TABLE 38
IMPORTANT NEEDS IN EACH WAR AREA

		Publicly Supplied Water	Industrial Self-Supplied Water	Rural Water Supply	Irrigation Water	Power Plant Cooling	Hydroelectric Power Generation	Commercial Navigation	Recreational Boating	Water Recreation	Fish and Wildlife	Water Quality Maintenance	Flood Damage Reduction	Drainage Control	Erosion Control	Health	Visual and Cultural
1	ST. JOHN RIVER BASIN	X	X		X				X	X	X						
2	PENOBSCOT RIVER BASIN		X							X		X					X
3	KENNEBEC RIVER BASIN	X	X														X
4	ANDROSCOGGIN RIVER BASIN	X	X			X				X	X	X	X				X
5	MAINE COASTAL BASINS	X	X			X				X	X						X
6	SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE	X	X	X		X		X									
7	MERRIMACK RIVER BASIN									X	X	X	X				X
8	CONNECTICUT RIVER BASIN									X	X	X					X
9	SOUTHEASTERN NEW ENGLAND	X	X			X			X	X		X				X	
10	THAMES AND HOUSATONIC RIVER BASINS	X	X							X		X					
11	LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE	X	X														X
12	HUDSON RIVER BASIN	X	X									X	X				
13	SOUTHEASTERN NEW YORK METROPOLITAN AREA	X							X	X		X					X
14	NORTHERN NEW JERSEY	X							X	X	X	X	X				
15	DELAWARE RIVER BASIN	X	X					X		X	X	X	X				
16	COASTAL NEW JERSEY	X	X									X					
17	SUSQUEHANNA RIVER BASIN	X	X							X		X					
18	CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE											X					X
19	POTOMAC RIVER BASIN	X										X			X		X
20	RAPPAHANNOCK AND YORK RIVER BASINS	X	X	X						X	X						
21	JAMES RIVER BASIN		X			X		X									

TABLE 39
RANKING OF HAR AREAS
BY SIZES OF THEIR NEEDS

The rank shown is the highest that the Area achieved for that need during any planning period, including 1980, 2000 and 2020, and the present.

		Publicly Supplied Water	Industrial Self-Supplied Water	Rural Water Supply	Agricultural Irrigation Water	Power Plant Cooling, Fresh Water Withdrawal	Power Plant Cooling, Fresh Water Consumption	Hydroelectric Power Generation	Commercial Navigation	Recreational Boating	Water Recreation Visitor Days	Sport Fishing Man-Days	Hunting Man-Days	Nature Study Man-Days	Water Quality Maintenance	Flood Damage Reduction, Upstream	Flood Damage Reduction, Mainstream	Flood Damage Reduction, Tidal and Hurricane	Drainage, Cropland	Erosion, Agriculture	Erosion, Urban	Erosion, Streambank	Visual and Cultural, Maintenance of Unique Natural Areas	Visual and Cultural, Maintenance of Unique Shorelines	Visual and Cultural, Maintenance of High Quality Areas	Visual and Cultural, Maintenance of Diverse Areas	Visual and Cultural, Development of Metropolitan Amenities	Visual and Cultural, Development of Quality Areas
1	ST. JOHN RIVER BASIN	21	18	16	5	7	11	10	19	20	21	20	21	21	11	19	19	11	11	10	21	19	1	12	10	11	13	7
2	PENOBSCOT RIVER BASIN	18	8	20	16	8	8	9	12	17	19	17	16	18	6	18	18	11	16	19	18	16	5	12	1	11	13	7
3	KENNEBEC RIVER BASIN	17	17	18	11	7	15	6	18	16	18	19	19	19	14	15	15	11	10	14	19	15	18	12	2	11	13	7
4	ANDROSCOGGIN RIVER BASIN	18	13	21	12	10	15	7	19	19	20	18	20	17	12	15	12	11	17	21	20	16	9	12	4	11	13	7
5	MAINE COASTAL BASINS	19	14	15	17	18	18	13	14	16	17	16	18	17	15	17	20	10	13	12	11	19	11	1	4	11	13	7
6	SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE	14	16	14	14	17	17	11	7	12	13	8	11	15	19	11	15	9	16	14	15	16	4	8	6	11	13	7
7	MERRIMACK RIVER BASIN	12	13	15	11	6	6	10	19	11	9	13	13	13	16	10	8	11	18	18	11	14	7	12	8	11	9	6
8	CONNECTICUT RIVER BASIN	10	4	9	8	5	4	3	11	7	8	9	6	9	7	6	6	11	7	9	5	9	4	12	6	11	13	7
9	SOUTHEASTERN NEW ENGLAND	3	8	13	5	19	19	16	6	2	3	2	7	3	4	2	11	3	19	17	6	12	9	10	10	11	5	2
10	THAMES AND HOUSATONIC RIVER BASINS	7	10	6	11	12	8	3	9	3	3	11	15	7	14	5	10	2	10	12	9	12	18	4	10	10	5	1
11	LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE	14	10	9	6	9	7	2	14	14	14	10	5	14	18	14	7	11	3	7	15	6	2	12	9	7	13	7
12	HUDSON RIVER BASIN	7	4	4	4	4	3	1	8	6	7	14	10	9	5	5	4	11	5	3	3	8	1	12	1	2	5	7
13	SOUTHEASTERN NEW YORK METROPOLITAN AREA	1	19	7	2	19	19	19	4	1	2	1	11	1	1	21	14	1	21	18	4	19	18	4	10	7	3	7
14	NORTHERN NEW JERSEY	3	6	10	10	15	11	11	1	4	4	15	8	4	3	12	1	11	10	11	6	5	18	12	10	9	3	4
15	DELAWARE RIVER BASIN	2	1	2	1	2	1	3	1	3	1	3	1	2	1	6	3	6	4	5	2	3	10	11	10	1	1	7
16	COASTAL NEW JERSEY	12	21	17	3	19	19	19	16	14	12	6	16	12	14	19	21	5	10	16	13	10	14	9	10	11	11	5
17	SUSQUEHANNA RIVER BASIN	6	2	1	1	1	1	1	17	10	3	4	1	5	6	3	2	11	2	1	1	1	3	12	10	4	2	7
18	CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE	7	7	4	3	14	10	18	4	6	15	7	6	7	10	1	13	4	1	7	4	7	13	2	10	4	9	2
19	POTOMAC RIVER BASIN	5	4	1	5	4	2	7	12	7	10	2	3	3	8	1	4	11	4	2	3	2	6	3	10	3	8	7
20	RAPPAHANNOCK AND YORK RIVER BASINS	16	16	7	15	8	3	15	10	11	15	17	11	16	19	13	17	8	7	6	16	10	6	7	10	3	13	7
21	JAMES RIVER BASIN	10	2	5	13	2	4	5	3	12	10	8	4	10	4	9	9	7	7	4	8	4	17	4	10	11	12	7

TABLE 40
RANKING OF HAR AREAS
BY SIZES OF THEIR NEEDS PER CAPITA

The rank shown is the highest that the Area achieved for that need during any planning period, including 1980, 2000 and 2020, and the present.

		Publicly Supplied Water	Industrial Self-Supplied Water	Rural Water Supply	Agricultural Irrigation Water	Power Plant Cooling, Fresh Water Withdrawal	Power Plant Cooling, Fresh Water Consumption	Hydroelectric Power Generation	Commercial Navigation	Recreational Boating	Water Recreation Visitor Days	Sport Fishing Man-Days	Hunting Man-Days	Nature Study Man-Days	Water Quality Maintenance	Flood Damage Reduction, Upstream	Flood Damage Reduction, Mainstream	Flood Damage Reduction, Tidal and Hurricane	Drainage, Cropland	Erosion, Agriculture	Erosion, Urban	Erosion, Streambank	Visual and Cultural, Maintenance of Unique Natural Areas	Visual and Cultural, Maintenance of Unique Shorelines	Visual and Cultural, Maintenance of High Quality Areas	Visual and Cultural, Maintenance of Diverse Areas	Visual and Cultu..., Development of Metropolitan Amenities	Visual and Cultural, Development of Quality Areas
1	ST. JOHN RIVER BASIN	20	4	1	1	1	1	3	19	3	12	4	3	8	2	17	11	11	3	2	7	9	1	12	10	12	13	7
2	PENOBSCOT RIVER BASIN	6	1	6	9	2	3	3	5	1	7	4	1	3	1	16	13	11	5	10	2	6	2	12	1	12	13	7
3	KENNEBEC RIVER BASIN	4	4	5	2	1	4	1	17	1	4	4	4	5	4	7	5	11	2	7	3	4	18	12	2	11	13	7
4	ANDROSCOGGIN RIVER BASIN	17	2	13	3	4	5	3	19	5	10	3	6	2	3	7	2	11	8	12	4	8	8	12	3	12	13	7
5	MAINE COASTAL BASINS	18	2	3	10	15	13	8	8	2	2	1	5	11	5	15	18	9	4	6	1	10	4	1	4	12	13	7
6	SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE	14	13	12	9	16	16	9	1	2	2	2	8	14	12	2	15	10	13	14	8	19	7	4	5	12	13	7
7	MERRIMACK RIVER BASIN	4	14	17	8	3	5	10	19	7	1	9	12	4	14	1	3	11	17	16	5	17	10	12	9	12	1	3
8	CONNECTICUT RIVER BASIN	6	7	14	5	4	3	4	13	9	7	11	13	1	9	3	4	11	11	11	5	15	6	12	7	12	13	7
9	SOUTHEASTERN NEW ENGLAND	2	18	20	11	19	19	17	10	8	16	15	19	16	16	13	17	6	20	20	19	20	14	10	10	12	9	5
10	THAMES AND HOUSATONIC RIVER BASINS	3	17	19	17	13	12	7	9	3	4	17	18	6	19	4	12	1	17	17	15	19	18	6	10	8	3	1
11	LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE	13	6	3	3	10	2	1	13	9	6	5	2	7	10	11	1	11	1	4	10	1	3	12	6	5	13	7
12	HUDSON RIVER BASIN	13	11	6	4	3	4	3	7	11	10	20	17	20	7	8	6	11	10	6	13	14	8	12	5	2	4	7
13	SOUTHEASTERN NEW YORK METROPOLITAN AREA	1	21	20	15	19	19	19	12	11	19	18	21	2	9	21	20	3	21	21	21	21	18	9	10	8	11	7
14	NORTHERN NEW JERSEY	1	17	18	19	15	15	13	3	15	17	21	19	20	6	19	4	11	19	19	19	12	18	12	10	9	8	6
15	DELAWARE RIVER BASIN	4	6	14	2	5	4	10	5	16	15	19	11	4	6	17	12	8	14	12	14	9	16	11	10	3	2	7
16	COASTAL NEW JERSEY	8	20	18	1	19	19	19	16	16	14	2	15	1	8	20	21	1	14	16	12	11	11	7	10	12	6	1
17	SUSQUEHANNA RIVER BASIN	7	10	4	6	1	2	4	18	18	10	13	8	9	17	9	6	11	8	3	6	2	11	12	10	6	3	7
18	CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE	8	12	6	3	14	13	18	3	11	21	11	15	17	18	1	18	4	2	11	10	13	15	3	10	4	6	2
19	POTOMAC RIVER BASIN	10	14	10	10	7	3	13	15	19	20	14	11	4	20	7	9	11	10	7	15	4	13	8	10	5	9	7
20	RAPPAHANNOCK AND YORK RIVER BASINS	20	8	2	6	7	1	13	6	17	8	9	3	2	10	2	15	5	2	1	5	4	5	2	10	1	13	7
21	JAMES RIVER BASIN	11	5	7	16	1	1	7	2	17	15	12	10	7	7	10	9	7	11	5	13	3	16	5	10	12	11	7

TABLE 41
RANKING OF BAR AREAS
BY GROWTH RATES OF THEIR NEEDS

The rank shown is the highest that the Area achieved for that need's growth rate during the 1980 to 2020 planning periods.

		Publicly Supplied Water	Industrial Self-Supplied Water	Rural Water Supply	Agricultural Irrigation Water	Power Plant Cooling, Fresh Water Withdrawal	Power Plant Cooling, Fresh Water Consumption	Hydroelectric Power Generation	Commercial Navigation	Recreational Boating	Water Recreation Visitor Days	Sport Fishing Man-Days	Hunting Man-Days	Nature Study Man-Days	Water Quality Maintenance	Flood Damage Reduction, Upstream	Flood Damage Reduction, Mainstream	Flood Damage Reduction, Tidal and Hurricane	Drainage, Cropland	Erosion, Agriculture	Erosion, Urban	Erosion, Streambank	Visual and Cultural, Maintenance of Unique Natural Areas	Visual and Cultural, Maintenance of Unique Shorelines	Visual and Cultural, Maintenance of High Quality Areas	Visual and Cultural, Maintenance of Diverse Areas	Visual and Cultural, Development of Metropolitan Amenities	Visual and Cultural, Development of Quality Areas
1	ST. JOHN RIVER BASIN	11	1	6	1	9	1	2	19	17	18	18	11	17	5	10	14	11	1	10	13	1	4	12	9	11	2	7
2	PENOBSCOT RIVER BASIN	6	4	18	6	10	12	11	2	14	17	21	21	21	4	12	17	11	5	17	18	5	9	12	6	11	2	7
3	KENNEBEC RIVER BASIN	19	16	10	2	1	1	12	9	2	19	2	10	11	13	18	15	11	2	12	19	8	12	12	1	10	2	7
4	ANDROSCOGGIN RIVER BASIN	20	19	15	4	1	1	14	19	21	21	5	17	16	12	9	13	11	4	3	20	8	12	12	7	11	2	7
5	MAINE COASTAL BASINS	18	6	7	8	1	1	18	1	20	20	20	19	20	6	13	20	10	3	19	21	1	8	1	7	11	2	7
6	SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE	10	13	9	16	1	1	18	6	7	15	11	13	12	18	6	5	5	11	9	10	21	12	11	1	11	2	7
7	MERRIMACK RIVER BASIN	16	12	20	18	21	18	8	19	8	12	9	8	8	19	5	10	11	8	2	4	6	12	12	1	11	[illegible]	1
8	CONNECTICUT RIVER BASIN	13	10	13	11	15	15	13	14	5	14	3	2	2	10	3	8	11	9	13	5	8	7	12	1	11	2	7
9	SOUTHEASTERN NEW ENGLAND	9	17	19	14	18	19	18	5	3	16	12	12	9	20	8	11	7	12	11	7	20	5	11	9	11	2	1
10	THAMES AND HOUSATONIC RIVER BASINS	8	9	17	20	1	1	5	4	1	10	7	7	6	21	2	7	4	10	8	2	8	12	11	9	1	1	1
11	LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE	15	18	12	3	12	11	15	16	15	13	19	20	19	17	19	12	11	7	4	14	8	10	12	1	1	2	7
12	HUDSON RIVER BASIN	5	8	14	7	11	10	6	11	4	3	17	18	18	9	14	16	11	6	16	16	8	12	12	9	1	2	7
13	SOUTHEASTERN NEW YORK METROPOLITAN AREA	21	14	21	21	18	19	16	13	6	9	15	14	14	11	21	19	9	21	21	17	1	12	11	9	11	2	7
14	NORTHERN NEW JERSEY	3	21	16	19	1	1	7	15	9	6	16	16	15	7	11	18	11	13	15	8	8	12	12	9	1	2	1
15	DELAWARE RIVER BASIN	17	3	5	15	17	13	10	10	11	8	10	4	5	3	16	9	6	14	5	6	8	12	11	9	1	2	7
16	COASTAL NEW JERSEY	1	2	8	13	18	19	16	3	12	2	13	9	10	14	17	21	8	15	18	12	8	11	11	9	11	2	1
17	SUSQUEHANNA RIVER BASIN	7	7	11	5	14	14	9	12	10	7	8	6	7	16	1	4	11	18	7	11	7	12	12	9	1	2	7
18	CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE	14	5	3	9	1	1	18	8	13	5	14	15	13	15	20	6	3	16	1	1	8	11	11	9	1	2	1
19	POTOMAC RIVER BASIN	2	11	4	10	13	17	3	17	18	1	1	1	1	8	4	1	11	20	6	3	8	11	11	9	1	2	7
20	RAPPAHANNOCK AND YORK RIVER BASINS	4	20	1	17	1	1	1	7	19	4	4	3	3	1	15	2	1	19	20	15	4	11	11	9	2	2	7
21	JAMES RIVER BASIN	12	15	2	12	16	16	4	18	16	11	6	5	4	2	7	3	2	17	14	9	8	11	11	9	11	2	7

TABLE 42
KEY DEVICES IN EACH NAR AREA

		Storage Facilities	Withdrawal Facilities	Wells	Conveyance Facilities (Diversions)	Quality Control, Temperature (Power Plant Cooling)	Quality Control, Chemical/Biological	Monitoring Facilities	Flood Plain Management	Local Flood Protection	Watershed Management	Erosion Protection	Drainage Practices	Waterway Management	Recreational Boating Facilities	Land Controls	Land Facilities	Habitat Management	Fisheries	Stocking	Insect Control	Research	Education	Water Demand and Allocation Changes	Project Operation Changes
1	ST. JOHN RIVER BASIN																								
2	PENOBSCOT RIVER BASIN																								
3	KENNEBEC RIVER BASIN						X																		
4	ANDROSCOGGIN RIVER BASIN						X									X									
5	MAINE COASTAL BASINS																								
6	SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE																								
7	MERRIMACK RIVER BASIN																								
8	CONNECTICUT RIVER BASIN																								
9	SOUTHEASTERN NEW ENGLAND						X					X													
10	THAMES AND HOUSATONIC RIVER BASINS																	X							
11	LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE																								
12	HUDSON RIVER BASIN																								
13	SOUTHEASTERN NEW YORK METROPOLITAN AREA						X																		
14	NORTHERN NEW JERSEY																								
15	DELAWARE RIVER BASIN						X																		
16	COASTAL NEW JERSEY																								
17	SUSQUEHANNA RIVER BASIN																								
18	CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE																								
19	POTOMAC RIVER BASIN																								
20	RAPPAHANNOCK AND YORK RIVER BASINS																								
21	JAMES RIVER BASIN																								

TABLE 43
IMPORTANT DEVICES IN EACH HAR AREA

	Storage Facilities	Withdrawal Facilities	Wells	Conveyance Facilities (Diversions)	Quality Control, Temperature (Power Plant Cooling)	Quality Control, Chemical/Biological	Monitoring Facilities	Flood Plain Management	Local Flood Protection	Watershed Management	Erosion Prevention	Drainage Practices	Waters y Management	Recreational Boating Facilities	Land Controls	Land Facilities	Habitat Management	Fishways	Poaching	Insect Control	Research	Education	Major Demand and Allocation Changes	Project Operation Changes
1 ST. JOHN RIVER BASIN						X									X					X				
2 PENOBSCOT RIVER BASIN															X									
3 KENNEBEC RIVER BASIN						X																		
4 ANDROSCOGGIN RIVER BASIN						X									X									
5 MAINE COASTAL BASINS																								
6 SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE																								
7 MERRIMACK RIVER BASIN		X																						
8 CONNECTICUT RIVER BASIN	X			X	X	X																		
9 SOUTHEASTERN NEW ENGLAND				X		X				X					X		X						X	
10 THAMES AND HOUSATONIC RIVER BASINS	X					X																		
11 LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE						X				X						X	X							
12 HUDSON RIVER BASIN	X	X				X																		
13 SOUTHEASTERN NEW YORK METROPOLITAN AREA				X		X																		
14 NORTHERN NEW JERSEY	X	X		X		X																		
15 DELAWARE RIVER BASIN	X	X	X		X	X																		
16 COASTAL NEW JERSEY																								
17 SUSQUEHANNA RIVER BASIN	X	X			X	X																		
18 CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE						X									X									
19 POTOMAC RIVER BASIN						X																		
20 RAPPAHANNOCK AND YORK RIVER BASINS																								
21 JAMES RIVER BASIN																								

TABLE 44
NEEDS IN EACH NAR AREA LIKELY TO
HAVE LARGE BENEFITS WHEN FULFILLED

		Publicly Supplied Water	Industrial Self-Supplied Water	Rural Water Supply	Irrigation Water	Power Plant Cooling	Hydroelectric Power Generation	Commercial Navigation	Recreational Boating	Water Recreation	Fish and Wildlife	Water Quality Maintenance	Flood Damage Reduction	Drainage Control	Erosion Control	Health	Visual and Cultural
1	ST. JOHN RIVER BASIN											X					
2	PENOBSCOT RIVER BASIN	X	X			X				X	X	X					X
3	KENNEBEC RIVER BASIN	X	X			X						X					
4	ANDROSCOGGIN RIVER BASIN									X		X			X		
5	MAINE COASTAL BASINS							X		X	X						X
6	SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE	X	X			X				X		X					
7	MERRIMACK RIVER BASIN											X					
8	CONNECTICUT RIVER BASIN	X	X							X	X	X					X
9	SOUTHEASTERN NEW ENGLAND	X	X			X						X					
10	THAMES AND HOUSATONIC RIVER BASINS	X						X				X					
11	LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE																
12	HUDSON RIVER BASIN											X					X
13	SOUTHEASTERN NEW YORK METROPOLITAN AREA	X										X					
14	NORTHERN NEW JERSEY											X	X				
15	DELAWARE RIVER BASIN		X			X		X		X	X	X					X
16	COASTAL NEW JERSEY	X							X	X	X	X					X
17	SUSQUEHANNA RIVER BASIN					X				X	X	X					X
18	CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE							X		X	X	X					X
19	POTOMAC RIVER BASIN	X	X							X							X
20	RAPPAHANNOCK AND YORK RIVER BASINS	X	X		X									X	X		
21	JAMES RIVER BASIN					X		X				X					

TABLE 45
RANKING OF DEVICE COSTS WITHIN EACH BAR AREA BY SIZES

The rank shown is the highest that the device cost achieved for that Area during the three planning periods, including 1980, 2000 and 2020.

	Storage, Upstream	Storage, Mainstream	Groundwater	Desalting	Interbasin Transfers	Public Water Supply Conveyance and Treatment	Industrial Self-Supplied Water Conveyance	Agriculture Irrigation Water Conveyance	Non-Agriculture Irrigation Water Conveyance	Power Plant Cooling Water	Commercial Navigation	Recreational Boating	Water Recreation	Fishing Access	Secondary Waste Treatment	Advanced Waste Treatment	Combined Sewer Overflows Control and Acid Mine Drainage Control	Upstream Flood Damage Reduction	Mainstream Flood Damage Reduction	Drainage Control	Erosion Control	Visual and Cultural
1 ST. JOHN RIVER BASIN	9	3	3	17	17	7	13	6	12	5	17	14	2	13	1	2	4	10	17	11	8	3
2 PENOBSCOT RIVER BASIN	7	1	6	17	17	5	9	12	12	4	3	10	2	10	1	2	3	7	17	10	6	4
3 KENNEBEC RIVER BASIN	9	15	5	15	15	1	13	7	9	3	15	9	1	10	1	2	3	15	15	9	7	4
4 ANDROSCOGGIN RIVER BASIN	10	14	5	16	6	4	11	9	7	3	16	9	2	10	1	2	3	6	4	11	7	16
5 MAINE COASTAL BASINS	8	18	5	18	18	4	10	15	6	3	4	12	10	8	1	2	3	9	18	10	7	2
6 SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE	8	18	8	19	18	7	13	16	10	2	2	9	3	12	1	1	2	6	18	14	6	4
7 MERRIMACK RIVER BASIN	3	6	1	19	3	6	15	16	10	9	19	14	2	12	1	4	2	8	9	16	6	4
8 CONNECTICUT RIVER BASIN	7	6	2	19	19	8	12	12	9	5	10	13	1	11	1	3	2	10	19	13	5	4
9 SOUTHEASTERN NEW ENGLAND	6	12	11	20	4	6	14	16	10	8	6	11	2	12	1	3	1	14	7	15	1	3
10 THAMES AND HOUSATONIC RIVER BASINS	6	4	10	16	19	2	14	18	21	8	3	11	1	14	2	7	1	8	7	7	4	2
11 LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE	8	5	5	17	17	4	15	10	9	2	17	13	2	12	1	17	1	13	8	8	4	2
12 HUDSON RIVER BASIN	2	2	2	18	18	3	14	1	10	3	5	12	1	16	1	1	2	11	9	14	5	1
13 SOUTHEASTERN NEW YORK METROPOLITAN AREA	15	15	9	5	3	5	1	13	8	15	2	2	1	6	1	2	1	15	6	13	8	1
14 NORTHERN NEW JERSEY	3	8	12	20	4	5	11	19	3	10	2	8	1	21	1	2	2	12	1	15	7	5
15 DELAWARE RIVER BASIN	7	8	10	21	12	6	11	19	9	5	1	11	1	16	1	2	16	10	8	15	5	2
16 COASTAL NEW JERSEY	22	7	21	4	14	13	12	8	9	1	6	5	8	7	1	2	5	14	1	10	2	2
17 SUSQUEHANNA RIVER BASIN	3	5	1	19	19	6	15	12	11	4	19	18	1	13	1	1	19	10	6	11	1	1
18 CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE	6	18	1	2	2	9	8	8	22	1	1	7	5	11	1	5	18	10	6	9	1	3
19 POTOMAC RIVER BASIN	11	5	4	20	14	2	14	15	12	8	19	20	1	13	1	6	19	8	9	16	1	1
20 RAPPAHANNOCK AND YORK RIVER BASINS	8	4	1	18	18	5	12	1	20	19	3	8	2	11	1	2	18	1	4	9	4	1
21 JAMES RIVER BASIN	1	8	20	2	16	4	14	8	9	7	2	21	6	22	1	2	17	6	3	13	1	3

TABLE 46
RANKING OF BAR AREAS
BY SIZES OF THEIR DEVICE COSTS

The rank shown is the highest that the Area achieved for that device cost during the three planning periods, including 1980, 2000 and 2020.

		Storage, Upstream	Storage, Mainstream	Groundwater	Desalting	Interbasin Transfers	Public Water Supply Conveyance and Treatment	Industrial Self-Supplied Water Conveyance	Agriculture Irrigation Water Conveyance	Non-Agriculture Irrigation Water Conveyance	Power Plant Cooling Water	Commercial Navigation	Recreational Boating	Water Recreation	Fishing Access	Secondary Waste Treatment	Advanced Waste Treatment	Combined Sewer Overflows Control and Acid Mine Drainage Control	Upstream Flood Damage Reduction	Mainstream Flood Damage Reduction	Drainage Control	Erosion Control	Visual and Cultural
1	ST. JOHN RIVER BASIN	9	7	5	5	7	16	19	1	20	13	13	20	15	21	19	10	15	7	13	11	17	18
2	PENOBSCOT RIVER BASIN	13	13	9	5	7	19	12	4	20	12	4	15	12	18	16	6	11	4	13	13	19	15
3	KENNEBEC RIVER BASIN	12	13	9	5	7	14	20	3	18	13	13	17	11	19	21	13	10	19	13	9	18	14
4	ANDROSCOGGIN RIVER BASIN	15	15	17	5	7	16	16	5	18	16	13	20	14	16	20	11	11	13	8	16	19	21
5	MAINE COASTAL BASINS	8	13	14	5	7	14	14	6	17	6	6	17	21	16	17	15	14	10	13	12	18	16
6	SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE	6	13	10	5	7	15	16	16	15	5	4	7	12	10	14	17	8	7	13	13	13	12
7	MERRIMACK RIVER BASIN	3	5	12	5	1	9	15	10	12	16	13	14	9	10	10	14	5	4	11	15	10	11
8	CONNECTICUT RIVER BASIN	2	4	4	5	7	8	6	7	8	4	7	14	5	9	8	8	4	5	13	6	7	5
9	SOUTHEASTERN NEW ENGLAND	1	6	6	5	2	7	9	10	3	4	3	5	1	3	8	5	2	7	4	17	1	9
10	THAMES AND HOUSATONIC RIVER BASINS	4	4	7	4	7	3	6	12	7	7	2	7	3	9	13	14	7	3	5	10	2	6
11	LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE	6	9	5	5	7	10	16	11	12	5	13	15	12	13	15	21	9	6	11	1	13	11
12	HUDSON RIVER BASIN	2	1	2	5	7	4	5	2	5	3	5	8	2	13	5	4	6	8	10	2	11	7
13	SOUTHEASTERN NEW YORK METROPOLITAN AREA	20	13	2	5	1	6	9	20	2	20	7	1	3	1	2	1	1	19	1	21	13	4
14	NORTHERN NEW JERSEY	2	2	10	5	1	3	3	15	7	12	4	3	6	15	1	2	3	6	1	11	9	7
15	DELAWARE RIVER BASIN	1	2	4	5	2	2	1	2	1	1	1	9	5	5	1	1	16	3	6	3	3	1
16	COASTAL NEW JERSEY	14	11	16	3	7	21	17	7	14	13	8	2	19	4	11	12	13	19	2	8	7	9
17	SUSQUEHANNA RIVER BASIN	3	1	1	5	7	5	3	2	2	1	13	11	1	6	5	3	17	1	4	2	1	7
18	CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE	1	13	3	2	2	12	2	1	10	15	3	2	13	3	9	12	17	4	6	1	3	1
19	POTOMAC RIVER BASIN	5	1	2	5	7	1	6	6	4	7	13	1	9	2	5	4	17	1	1	4	4	2
20	RAPPAHANNOCK AND YORK RIVER BASINS	10	3	8	5	7	15	13	18	16	20	8	13	19	15	13	6	17	3	5	4	15	12
21	JAMES RIVER BASIN	13	6	6	1	4	3	3	14	10	10	1	9	11	8	4	4	17	1	3	5	6	17

TABLE 47
RANKING OF HAR AREAS BY SIZES
OF THEIR DEVICE COSTS PER CAPITA

The rank shown is the highest that the Area achieved for that device cost during the three planning periods, including 1980, 2000 and 2020.

	Storage, Upstream	Storage, Mainstream	Groundwater	Desalting	Interbasin Transfers	Public Water Supply Conveyance and Treatment	Industrial Self-Supplied Water Conveyance	Agriculture Irrigation Water Conveyance	Non-Agriculture Irrigation Water Conveyance	Power Plant Cooling Water	Commercial Navigation	Recreational Boating	Water Recreation	Fishing Access	Secondary Waste Treatment	Advanced Waste Treatment	Combined Sewer Overflow Control and Acid Mine Drainage Control	Upstream Flood Damage Reduction	Mainstream Flood Damage Reduction	Drainage Control	Erosion Control	Visual and Cultural
1 ST. JOHN RIVER BASIN	1	1	1	5	7	3	6	1	7	4	13	12	4	8	1	2	11	3	13	2	8	8
2 PENOBSCOT RIVER BASIN	8	13	10	5	7	8	1	3	13	2	1	4	2	2	1	1	6	2	13	4	17	2
3 KENNEBEC RIVER BASIN	6	13	2	5	7	1	6	2	3	5	13	3	1	6	7	4	5	19	13	3	14	1
4 ANDROSCOGGIN RIVER BASIN	9	13	3	5	7	5	4	4	2	7	13	9	7	1	6	3	7	3	1	7	17	21
5 MAINE COASTAL BASINS	6	13	3	5	7	3	2	6	1	1	3	7	20	3	3	5	12	6	13	5	16	2
6 SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE	5	13	7	5	7	15	13	15	4	3	1	1	11	1	9	12	9	3	13	12	4	8
7 MERRIMACK RIVER BASIN	1	2	12	5	1	6	15	12	10	16	13	14	6	8	8	13	4	2	5	16	1	5
8 CONNECTICUT RIVER BASIN	3	4	8	5	7	13	9	7	4	6	7	18	2	10	13	10	2	7	13	9	6	6
9 SOUTHEASTERN NEW ENGLAND	2	9	15	5	3	14	19	12	16	11	5	13	7	15	20	15	3	14	7	20	1	14
10 THAMES AND HOUSATONIC RIVER BASINS	4	4	11	5	7	1	10	15	6	9	4	7	1	18	20	18	13	7	3	17	3	9
11 LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE	1	2	3	5	7	5	11	3	1	2	13	11	12	8	11	21	10	6	7	1	5	4
12 HUDSON RIVER BASIN	3	3	7	5	7	7	14	6	7	4	6	9	2	20	12	9	14	13	8	10	15	6
13 SOUTHEASTERN NEW YORK METROPOLITAN AREA	20	13	15	5	2	17	20	20	21	20	10	15	13	5	11	2	1	19	5	21	21	18
14 NORTHERN NEW JERSEY	5	8	18	5	1	11	11	19	20	14	7	7	9	21	4	1	8	10	2	19	17	16
15 DELAWARE RIVER BASIN	2	10	14	5	3	9	4	10	11	7	3	19	12	17	5	6	16	7	10	15	12	9
16 COASTAL NEW JERSEY	10	11	16	3	7	21	19	6	15	13	8	1	20	1	14	14	15	19	1	10	2	7
17 SUSQUEHANNA RIVER BASIN	3	3	5	5	7	10	11	5	9	3	13	19	1	15	15	4	17	5	6	6	3	12
18 CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE	4	13	11	2	2	19	2	5	15	17	4	3	15	9	17	18	17	8	4	3	2	1
19 POTOMAC RIVER BASIN	9	3	10	5	7	1	17	10	16	12	13	5	13	7	18	5	17	4	1	11	10	3
20 RAPPAHANNOCK AND YORK RIVER BASINS	5	1	5	5	7	14	5	16	7	20	3	3	18	11	9	3	17	1	3	2	8	2
21 JAMES RIVER BASIN	17	5	8	1	4	2	8	14	13	10	2	8	15	12	4	7	17	1	4	8	4	20

The Tables of the Regional Programs show the needs, devices and costs in physical (numerical) terms whenever possible. Where it is only known that a device is used, and no magnitude is available, the number of Areas is indicated (within parentheses) in which it is used.

WATER MANAGEMENT

This Program is concerned with those needs which physically put water to use and with the prevention and treatment of pollution, generally following man's use of the water. These needs are described and an analysis is made of their general importance to this Program. Water must generally be delivered to the point of use for six of these needs: Publicly Supplied Water, Industrial Self-Supplied Water, Rural Water Supply, Agriculture and Non-Agriculture Irrigation Water, Navigation and Hydroelectric Power Generation.

Devices used to meet these needs generally have multiple uses and serve many withdrawal and instream purposes. Allocations were not made of the water developed to each of these and other Program needs.

The primary pollutants considered by water quality maintenance needs are heat, suspended solids, dissolved chemicals and toxic substances. The achievement of high water quality through this program is a key to the achievement of most of the goals of the Water Management and Environmental Management Programs.

Table 48 shows the needs, devices and costs of this portion of the mixed objective Regional Program. The following discussion describes these Program elements in the context of the Region: the Areas which have the largest and most rapidly growing needs, the applicability of each device in fulfilling these needs; and the benefits and costs that will result.

Needs

Publicly Supplied Water. The publicly supplied water need is among the most important needs of the NAR. The Areas with the largest publicly supplied water needs throughout the planning period are 9, 13, 14 and 15 and the growth rate of the need is highest throughout the planning period in Areas 2, 12, 14, 16, 19 and 20. This need is felt to be one of the most important needs in the achievement of two-thirds of the Areas' objective mixes which include Areas 1, 3, 4, 5, 6, 9, 10, 11, 12, 13, 16, 17, 19, and 20. This need is felt to be key to the achievement of other needs only in Area 13. The largest per capita publicly supplied water needs are presently found in Areas 9, 10, 13 and 15 but will change to Areas 3, 9, 13 and 14 by 2020.

Table 48
MIXED OBJECTIVE REGIONAL PROGRAM
WATER MANAGEMENT

NEEDS—cumulative		Pres.	1980	2000	2020
Publicly Supplied Water	(1000 mgd)	5.5	7.2	10.7	15.8
Industrial Self-Supplied Water	(1000 mgd)	3.9	7.2	13.1	21.8
Rural Water Supply	(mgd)	400	570	790	720
Irrigation Water: agriculture	(1000 afy)	150	540	730	760
non-agriculture	(1000 afy)	100	270	460	700
Hydroelectric Power Generation	(1000 mw)	5	14	42	102
Navigation: commercial	(m. tons annually)	600	760	1130	1790
recreational boating	(m. boats)	1.6	2.1	3.5	6.0
Power Plant Cooling:					
withdrawal, saline	(1000 cfs)	23	43	131	260
brackish	(1000 cfs)	12	29	42	45
fresh	(1000 cfs)	10	12	21	30
consumption, brackish	(cfs)	120	280	430	510
fresh	(cfs)	120	480	1180	2340
Water Quality Maint.: non-industrial	(m. PEs)	44	56	70	86
industrial	(m. PEs)	70	140	300	620

DEVICES—incremental		Purposes			
Storage Facilities:					
reservoirs, upstream	(1000 af)	FW * /	680	850	2260
mainstream	(1000 af)	FW,WQ * /	340	1240	2410
Withdrawal Facilities:					
intakes & pumping, fresh	(1000 mgd)	PS,Ind **	3.1	6.3	10.2
brackish	(1000 mgd)	Ind	2.6	4.5	6.9
estuarine		Pow	(7)	(11)	(11)
ocean		Pow	(11)	(14)	(14)
waste water	(mgd)	Ind	150	380	820
wells	(mgd)	*	660	1050	1220
Conveyance Facilities:					
inter-basin diversions, into	(mgd)	* /	500	1200	2300
out of	(mgd)	*	470	1200	2300
Quality Control Facilities:					
temperature, cooling towers & ponds		Pow,WQ,Rec	(14)	(18)	(21)
chemical/biological					
potable water treat. plants	(mgd)	PS	520	2200	3610
waste treatment plants					
secondary (85%)	(m. PE removed)	WQ,VC,Rec	55	0	0
secondary (90%)	(m. PE removed)	WQ,VC,Rec	120	340	640
advanced (95%)	(m. PE removed)	WQ,VC,Rec	6	17	35
effluent irrigation		WQ,VC,Irrig	(7)	(7)	(7)
nutrient control		WQ,VC,Rec	(20)	(20)	(20)
stormwater discharge control		WQ,VC,Rec	(18)	(14)	(14)
acid mine drainage control		WQ,VC	(3)	(3)	(3)
septic tank control		WQ,VC,Rec	(12)	(12)	(12)
separate combined sewers		WQ,VC,Rec	(20)	(15)	(15)

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.
** Also includes Pow, Irrig.
/ Also includes Rec, VC.
/ Includes 25 mgd from outside the Region, in 1980 only.
( ) Indicates number of basins to which applicable.

Table 48 (cont.)

DEVICES—incremental (cont.)	Purposes	1980	2000	2020
Pumped Storage	HPG	(7)	(11)	(13)
Desalting Facilities (mgd)	Ind *	10	200	210
Monitoring Facilities	WQ,WC,Rec	(11)	(11)	(11)
Waterway Management:				
navigation channel improvement	Nav	(13)	(14)	(8)
debris removal	WC	(2)	(2)	(2)
recreation boating facilities	Rec,Nav	(21)	(21)	(21)
FIRST COSTS—incremental ($ million 1970)				
Water Development Costs:				
storage, upstream /		180	170	500
mainstream /		170	360	700
wells /		210	210	140
desalting /		40	460	440
Water Withdrawal and Conveyance Costs:				
inter-basin transfers /		00	720	820
public water supply and treatment		380	1060	1430
industrial self-supplied water		30	54	83
irrigation, agriculture		62	54	17
non-agriculture		150	140	190
Navigation: commercial		920	1410	460
recreational		70	130	170
Power Plant Cooling Water		0	480	1360
Water Quality Maintenance:				
waste treatment, secondary		11000	25000	48000
advanced		950	3550	7310
comb. sewer overflow & acid mine drainage control		7500	0	0

* From the supply model for the following purposes: PS, Ind, Rur, Irrig, Pow.

/ From the supply model and includes OMR costs.

TABLE 49

MAJOR WATER DEVELOPMENT PROGRAM FOR MAR 1980 - 2020*
(million gallons per day in increments)

	Upstream Reservoirs			Mainstream Reservoirs			Groundwater			Desalting			Transfers OUT					Transfers IN				Total Developed in Basin			Total** Developed for Basin			
Area	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020	P	1980	2000	2020	To Area	1980	2000	2020	From Area	1980	2000	2020	1980	2000	2020	Area
1	24	16	0	27	49	120	17	17	26													68	82	146	68	82	146	1
2		13	0				2	3	1													2	16	1	2	16	1	2
3	3	14	0				6	15	5													9	29	5	9	29	5	3
4	5	4	0				4	7	3													9	11	3	9	11	3	4
5	5	11	55				5	4	5													10	15	60	10	15	60	5
6	31	66	103				9	11	5													40	77	108	40	77	108	6
7	1	2	457	24	769	367	3	7	6				290	118	486	743	9a,b	118	100	7	8c	28	778	830	28	298	197	7
8	21	227	0	123	67	370	28	13	-19				195	118	100	7	7b					172	307	351	54	13	344	8
9	149	0	0	30	0	0	30	10	8									118	486	743	7c	209	10	8	327	496	751	9
10	28	19	175	117	257	185	19	20	133			1										164	296	493	164	296	493	10
11	9	58	28		26	116	17	23	8													26	107	157	26	107	157	11
12	86	42	699	37	1272	757	45	55	4				1380	0	270	1015	13b, 14	0	0	0	15a	168	1369	1460	168	550	353	12
13							152	209	293									0	270	485	12c	152	209	293	152	479	778	13
14	140	0	0		150	0	9	119	16									35	300	530	15b, 12c	149	269	16	184	569	546	14
15	39	55	761	11	54	319	27	43	207				605	35	300	0	12c, 14	37	0	0	17e	76	152	1287	62	67	647	15
16	12	0	0			35			36			6										12	0	77	12	0	77	16
17	67	40	66	299	351	1146	89	230	32				90	199	38	530	15d, 18a					455	621	1244	256	493	715	17
18	13	209	0				18	150	0		113	86	40	0	0	0	19c	162	38	530	17e	31	472	86	193	510	616	18
19	18	14	2	199	412	580	55	-16	120									0	0	0	18a	272	410	702	272	410	702	19
20	1	3	0	85	43	15	7	13	11													93	59	26	93	59	26	20
21	7	1	0	22	249	225	10	51	262	12	85	119						25	0	0	Chow. River	51	386	606	76	386	606	21
Chowan River	25	0	0										25	25	0	0	21c					25	0	0				Chowan River
Total	684	794	2346	974	3699	4235	1172	1000	1181	12	198	212	2625	495	1194	2295		495	1194	2295		2842	5675	7954	2825	4963	7326	

* Contains all water development but does not consider effect of development on existing resources. The completion of the Tocks Island, Beltsville, Raystown and Gathright projects is assumed prior to 1980.

** Development for the basin includes the sums of ground water, minimum upstream storage for irrigation and the difference between the remaining storage and transfers out of the basin.

Industrial Self-Supplied Water. The industrial self-supplied water need is also among the most important in the NAR. This need is largest throughout the planning period in Areas 8, 12, 15, 17, 19 and 21. The Areas with the highest growth rate for this need are 1, 2, 15, 17 and 18. Industrial self-supplied water is considered to be one of the most important needs for the mixed objectives of two-thirds of the NAR Areas, including 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 16, 17, 20 and 21. In no Areas is the need felt to be key to the achievement of other needs. This need is largest on a per capita basis throughout the planning period in Areas 2, 4 and 5.

Rural Water. Rural water supply is one of the less important needs in the Region. Rural water needs are presently largest in Areas 12, 15, 17, 18 and 19 but this will change to Areas 15, 17, 18 and 19 by 2020. The highest growth rates for this need over the planning period appear in Areas 18, 19, 20 and 21. Rural water supply is considered important in two areas - 6 and 20 - but it is not felt to be a key need in any Area. The Areas where this is the largest per capita need include 1, 11 and 20 at present and 1, 5, 11 and 20 by the last planning period.

Irrigation Water. Irrigation water supply is considered to be one of the less important needs of the Region. For agriculture purposes, this need is presently largest in Areas 13, 15, 16 and 18 but changes to Areas 1, 12, 15, 17 and 18 by 2020. Agriculture irrigation needs have their highest growth rate in Areas 3 and 11; their largest per capita levels at present in Areas 15, 16 and 18 and by 2020 in Areas 1, 3, 4 and 11. Irrigation water for non-agricultural purposes will be largest in Areas 9, 13 and 15 throughout the planning period and will be growing most rapidly in Areas 1, 2, 5 and 20. This need is presently the largest on a per capita basis in Areas 6, 7, 8, 10 and 16 and by 2020 in Areas 4, 5 and 11. Irrigation water is considered to be important for achievement of the mixed objective only in Area 1 and in no Area is it considered to be key to the achievement of other needs.

Hydroelectric Power Generation. Hydroelectric power generation is one of the least important needs in the Region as it is not considered to be important to the achievement of the mixed objective in any Area of the NAR nor key to the fulfillment of any other needs in these Areas. Hydroelectric power generation as an adjunct to other power facilities is important from the viewpoint of the electric utility systems. The need for hydroelectric power generation is considerably higher in Areas 11 and 17 at the present time and is expected to be highest in Areas 12 and 17 from 1980 through 2020. The growth rate of this need for the entire planning period is expected to be highest in Areas 19 and 21 and highest in Area 1 from 1980 through 2020. This need presently has the largest per capita levels in Areas 2, 3, 4 and 11 and will have the largest per capita levels in Areas 1, 2, 3 and 11 by 2020.

Navigation. Navigation is considered to be among the less important needs of the Region. The commercial portion of navigation needs are expected to be largest in Areas 13, 14, 15, 18 and 21 throughout the planning period. Areas 2, 5, 6, 9 and 16 will have the fastest growing needs for commercial navigation. The per capita levels of this need will be largest throughout the planning period in Areas 6, 14 and 21. Commercial navigation is thought to be important for the achievement of the mixed objective of Area 6 and is thought to be key to other needs in Areas 15 and 21.

The recreational boating portion of navigation needs are expected to be largest in Areas 9, 10, 13, 14 and 15 throughout the planning period. This need will grow the fastest in Areas 3, 8, 9, 10 and 12. Per capita needs for recreational boating are now largest in Areas 2, 3, 5 and 6 and this will change to Areas 2, 3, 6 and 10 by 2020. Recreational boating will be one of the most important needs in Areas 1, 9 and 14 and it will be a key need in Areas 13 and 15.

Power Plant Cooling. Power plant cooling is considered as one of the most important needs in the Region. There are three types of power plant cooling needs, including the use of saline, brackish and fresh water. Saline withdrawal needs in the Region are the largest of the three types. Areas 9, 10, 13 and 14 presently need the most saline water and Areas 9, 13, 16 and 18 will need the most in 2020. The growth rates are largest for saline water withdrawal needs in Areas 5, 15, 16 and 18. The per capita levels of this need are presently largest in Areas 10, 14 and 20 and are expected to be largest by 2020 in Areas 5, 6 and 16. Brackish water withdrawal needs are next in size in the Region and are now largest in Areas 8, 12, 15, 18 and 19 and are expected to be largest by 2020 in Areas 12, 15, 16 and 18. Brackish water needs for power plant cooling will grow fastest in Areas 14, 15, 16, 18 and 21. The need now has the largest per capita level in Areas 8, 12 and 18 and will be largest in Areas 12, 15, 16, 18 and 21 by 2020.

Fresh water needs for power plant cooling will be largest in Areas 15, 17, 19 and 21 throughout the planning period. The growth rate for this need will be highest in Areas 1, 2, 3, 11 and 19. Per capita levels of this need are presently highest in Areas 7, 8, 17 and 21 and are expected to be the highest in Areas 1, 2 and 3 by 2020.

Power plant cooling needs are considered to be among the most important needs for achievement of the mixed objectives of Areas 4, 5, 6, 9 and 21. It is not considered to be a key to other needs in any portion of the Region.

The consumption of brackish water for power plant cooling will be large in Area 18 throughout the planning period; and among the largest in Area 12 during the first and second period and in Area 16 only during the third. Fresh water consumption for this need will be largest in Areas 15 and 17 throughout all planning periods with Area 12 becoming almost as large by 2020.

Water Quality. Water quality is one of the most important needs of the Region. It is considered to be important and a key need in more Areas than any of the other fifteen needs. Water quality is among the most important needs for achieving the mixed objectives of Areas 2, 4, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18 and 19. It is thought to be a key to the fulfillment of other needs in Areas 1, 2, 3, 4, 5, 7, 8, 9, 12, 13, 15, 16, 17, 18, 19 and 21. The largest water quality needs throughout the planning period will be in Areas 13, 14 and 15. This need will be growing most rapidly in Areas 15, 20 and 21

Devices

Water Development. Many new and enlarged sources of water are required in the NAR as the needs become larger and cannot be met either during periods of low flow or at points of large demand. Additional sources and quantities of water are required so that withdrawal and in-stream needs can be met during these critical periods. This portion of the Water Management Program is summarized in Table 49. This portion of the Program is based entirely on the computer supply model that develops water sources according to least costs and other constraints and assumptions described in Chapter 7 of Appendix T, Plan Formulation.

The water withdrawal needs involved are publicly supplied water, industrial self-supplied water, rural water supply, irrigation water and the consumptive portion of power plant cooling. The devices to provide this additional water include upstream storage, mainstream storage, desalting, groundwater development and transfers between Areas. There is no breakdown of the amount of water to be supplied to any one need by these devices, however, all withdrawal needs should be met throughout the planning period with the devices described in the next paragraph. In-stream needs should also be met by these devices since minimum in-stream flows and minimum basin outflows have been established sufficiently high for each Area. These in-stream needs include water recreation, fish and wildlife, visual and cultural, navigation, hydroelectric power generation and power plant cooling.

Mainstream reservoirs will be the primary new sources of water in the NAR. These reservoirs will be the primary sources of water for Areas 7, 8, 10, 17 and 20 throughout the planning period. Mainstream reservoirs will not be used in Areas 2, 3, 4, 5, 6, 13 and 18 and only a small amount during 2020 in Area 16. Mainstream reservoirs will provide the greatest amount of new sources of water in the last two planning periods for Areas 1, 12, 17, 19 and 21. Upstream reservoirs will be the largest new source of water only in Area 6 throughout the planning period. Upstream reservoirs will be the largest new sources through the first two planning periods in Area 16 and during the last two planning periods in Areas 2 and 5. This source will be largest during the first planning period in Areas 1, 5 and 14 and during the third period in Area 15.

Groundwater will be the largest source throughout the planning period only in Areas 3 and 4. Other new groundwater sources will be the largest in the first planning period in Areas 5, 9, 15, 19 and 21; in the last planning period in Area 16.

Desalting is included in the program for use in Areas 16, 18 and 21 and will be fairly large in Areas 18 and 21 during the last two planning periods. Some doubt has been expressed by the State of Virginia that this will be a practical device in their portion of the Region.

Transfers between Areas of the Region occur nine times in the Program and eight of these for all three planning periods. Three of the transfers stay at the same level throughout all planning periods: from Areas 15 to 12, 17 to 15; and 18 to 19. Some transfers are the largest sources of water for the Areas the water is going to: from Area 7 to 9 for all planning periods, from Area 17 to 18 in the first and third planning period, from Area 15 to 12 for the first planning period, and from Area 12 to 13 and Area 15 to 14 during the last two periods.

Three sources of water outside of the Region are considered and include Lake Ontario, St. Lawrence River and Chowan River. Only a possible increase in the present transfer from the Chowan River for Area 21 appears in the Program.

Publicly Supplied Water. River and lake intakes are and will continue to be the most commonly used withdrawal devices for publicly supplied water needs of the Region. The only parts of the Region in which the use of this device will not be expanded is in the Long Island portion of Area 13 through the first planning period and in the New York City portion of the Area throughout the planning period. Withdrawal devices are considered especially important to publicly supplied water needs in Areas 7, 12, 14, 15 and 17. Storage devices will also be important in fulfilling this need in Areas 10, 12, 14, 15, 17 and 21.

Wells are becoming increasingly important in the NAR. They are used throughout the Region although most rarely in Areas 3 and 4. Wells will be important to this need in Area 15. Groundwater management and recharge with treated sewage may become more common in the Region and will certainly be intensely sought in the Long Island portion of Area 13 where groundwater is the only major source of water. Mostly groundwater management will be used in Area 16 especially around the Pine Barrens where a minimum water table must be maintained for survival of the Pines. Large quantities of groundwater will be used in Area 17, because of its easy access and the historical use of this technology in the Area.

Flood skimming, a relatively new type of reservoir management will be increasingly used in the Region but especially in Areas 7, 8, 9, 12 and 14 where new water sources are scarce.

Diversions between basins will play an increasing roll in Areas 7, 9, 13, 14 and 18, and are considered to be of greatest importance for this need in Areas 9, 13 and 14. Underground storage may come into use in Area 14 because of the very large publicly supplied water need and the presence of the required geological conditions.

Potable water treatment plants are used with all publicly supplied water in the Region but the other quality control devices are becoming increasingly important. These devices will be most important for this need in Areas 1, 4, 7, 9, 10, 12 and 15.

Industrial Self-Supplied Water. River intakes are presently and will continue to be the most common withdrawal device for industrial water supply. Intakes on brackish and saline water bodies are becoming second in importance. Use of wells and of waste water intakes, while small, is growing at an increased rate. Wells will be especially important in Area 15 but withdrawal facilities will be of greatest importance in Areas 7, 12, 15 and 17. Storage will also be increasingly used for industrial needs and will be most important in Areas 10, 12, 15, 17 and 21. The quality of water is becoming of increasing concern to industry. This concern will be most important in Areas 1, 4, 7, 9, 10, 12 and 15.

Rural Water Supply. Wells are the primary source of rural water supply although increasing numbers of rural domestic needs are being met by central publicly supplied systems. An undetermined but probably a fairly large quantity of rural needs are met by farm ponds that collect runoff. Quality of groundwater is a rapidly increasing problem in some Areas, such as the eastern portion of Area 13, and quality control facilities must be increasingly used. Water quality control for this need will be most important for rural water needs in Area 1.

Irrigation Water. Sources of irrigation water are presently divided evenly between ground and surface waters in the Region as a whole. Decreasing needs for irrigation water will be reflected in decreasing use of reservoirs for this need after 1980. Only West Virginia varies extremely from this proportion where almost all of its irrigation water comes from surface sources. New York State presently varies the most in the other direction where almost three quarters of its irrigation is done with groundwater. Some irrigation is done with water from municipal systems but only in one state, Rhode Island, does this source reach any significant level, about one fifth of its total.

The Areas differ in the devices that will become important in meeting irrigation needs. Storage will be important in Areas 10, 17 and 21; withdrawal facilities in Areas 7 and 17, conveyance facilities in Areas 9, 13 and 17, and quality control in Areas 1, 7, 9, 10 and 17.

Effluent irrigation is only just becoming an accepted method for waste disposal and water reclamation. It is expected that the greatest growth in this type of irrigation will occur in Areas 9, 15 and 19. The use of this device may be controversial.

Hydroelectric Power Generation. Pumped storage facilities will be the primary sources of future hydroelectric power in the NAR. Only in Areas 1 and 20 will conventional storage provide new hydroelectric power because of the availability in these two Areas of large reservoir sites.

New pump storage facilities will be installed in all time periods in Areas 8, 10, 12, 15, 17 and 21. It is expected that additional pumped storage will be used in Areas 1, 7, 11 and 19 beginning with the second planning period and in Areas 2 and 4 beginning with the last period. The use of this device will be increased only during the second planning period in Area 1 and only during the first and third planning periods in Area 14. No pumped storage is likely to be installed in Areas 5, 6, 9, 13, 16, 18 and 20 throughout the planning period.

Commercial Navigation. Navigation channel improvements are used more than any other device to fulfill navigation needs in the NAR. This device is not used throughout the planning period in Areas 1, 3, 4, 7, 11 and 17. They are used throughout the planning period in Areas 2, 8, 9, 10 and 21. This device is likely to be used only during the first two planning periods in Areas 6, 13, 14, 15, 18 and 19, only during the second two periods in Areas 5 and 12, and during the first period in Area 20.

Offshore facilities for commercial navigation needs may appear in the first planning period in Areas 13, 14, 15, 19 and 21. This device may appear in the last planning period in Area 2 and in the last two periods in Areas 5, 6, 9, 10 and 18.

Navigation aids are also used wherever navigation occurs and these devices will be used in increasing numbers throughout the planning period.

Lightering may be an alternative for fulfilling navigation needs in certain Areas of the Region as it will prevent destruction of unique shorelines and pollution of inshore waters.

Diversion of cargo can be of similar protective usefulness.

Lock rehabilitation should only be necessary in the NAR in Area 11 during the second planning period.

Removal of obstructions is a continuous problem in most navigation waters of the Region.

Recreation Boating. Many commercial navigation devices are useful, if not necessary for recreational boating needs of the Region. Navigation channel improvement, port improvement, lock rehabilitation, obstruction removal, navigation aids and breakwater and jetty construction are the primary devices that serve this dual purpose in the NAR. These devices will be especially helpful to recreational boating in the NAR for Areas 2, 5, 9, 10, 13, 14 and 15. Some instream channel improvements and navigation aids will be necessary for recreational boating beyond those used for commercial navigation. These additional mainstream channel improvements will probably be necessary in Areas 8 and 15 in 2020: in Areas 20 and 21 in 1980; in Area 11 in 1980 and 2020, and in Area 19 in all planning periods. These additional navigation aids will be necessary in Areas 8, 11, 14, 19, 20 and 21 in all planning periods and in Area 10 in 1980.

Facilities designed only for the use of recreational boating will be used in all planning periods in all Areas of the NAR. The quantity of these facilities will be especially large in Areas 9, 10, 13, 14 and 15.

Power Plant Cooling. Cooling towers will be the primary means of meeting water quality temperature-standards for power plants in the NAR. This device will be used in almost the entire Region. Saline water with appropriate devices can probably be used to meet the power plant cooling needs of Areas 9 and 13 without raising the offshore ocean temperatures unduly. Cooling towers will not be used until the last planning period in Areas 1, 3 and 4. Cooling towers are considered to be an important device in Areas 8, 15 and 17.

Non-condensing power generating devices may be utilized in Areas 1, 6, 8, 9, 11, 12, 15, 17, 18, 19 and 21 in the second and third time periods; and in Areas 2, 4, 5 and 10 in 2020.

Water Quality Maintenance. Two levels of treatment – 90 and 95 percent – will be used throughout the Region except for advanced treatment (95 percent) in Area 11. Especially large amounts of treatment should be provided in Areas 13, 14 and 15 and generally large amounts in Areas 1, 2, 8, 9, 12, 17, 19 and 21. Even with these treatment levels reservoir storage is recommended to augment low flows in all planning periods of Areas 12, 14, 15, 17, 19, 20 and 21 and in the last two planning periods in Areas 1, 2, 3, 4, 5, 7, 8, 9, 10 and 16.

Water quality control facilities will be important in more Areas than any other devices. These Areas include 1, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18 and 19. These facilities will be key in Areas 3, 4, 9, 13 and 15.

Nutrient control should be used in the entire Region except for Area 2. Storm water discharge control should be used in all planning periods in Areas 1, 3, 5, 6, 7, 8, 9, 10, 15 and 17 through 21. This device should be used during the first planning period in Areas 11, 12, 13 and 14.

Septic tank controls are recommended for Areas 7 through 18 for all planning periods. Acid mine drainage control is a special problem in Areas 15, 17 and 19 and will require special devices in addition to research on better and cheaper methods.

Irrigation with treated effluent is recommended for Areas 6, 7, 13 and 16.

Special attention should be given to marine oil spills throughout the Region but especially in Area 9.

Monitoring of pollution should be carried out throughout the Region but receive special attention in Areas 5, 6, 7, 8, 10, 11, 12, 13, 15, 17 and 19.

Benefits

The use of upstream storage will produce large benefits in Areas 2, 5, 6 and 16 throughout the planning period. Benefits will be fairly large iin Areas 1, 5 and 14 during the first period and in Area 15 during the last period.

Mainstream storage will produce large benefits throughout the planning period in Areas 7, 8, 10, 17 and 20. During the last two periods this device will produce large benefits in Areas 1, 11, 12, 19 and 21.

Groundwater development will have large benefits only in Areas 3 and 4 throughout the planning period. There will be large local benefits from the use of groundwater, however, where it can be obtained cheaply and reduce the need of capital costs for the more expensive and environmentally degrading devices. Such local benefits will be of special importance in Areas 5, 11, 13, 14, 15, 17, 18, 19 and 21.

Desalting will also produce benefits of importance for small portions of Areas as it supplements the more conventional water sources. Portions of Areas 18 and 21 will receive these benefits.

Transfers of water will have large benefits where other sources are not available such as in Areas 9, 13, 14 and 18.

Benefits to publicly supplied water needs will be large in relation to costs in Areas 2, 3, 6, 8, 9, 10, 13, 16, 19 and 20. Industrial self-supplied water needs will receive large benefits in Areas 2, 3, 6, 8, 9, 15, 19 and 20.

No large amounts of benefits will accrue to rural water needs in any Areas.

Irrigation needs will receive large benefits only in Area 20. Many of the benefits that accrue to irrigation devices are not easily measured as they help fulfill visual and cultural needs for diversified landscapes.

Hydroelectric power generation will produce benefits throughout the Region but the benefits from pump storage devices will not be large in any particular area. Benefits from conventional hydroelectric power production will be large in Areas 1 and 20.

Benefits from Navigation programs should be large in Areas 5, 10, 15, 18 and 21 and recreational boating benefits should be large in Area 16.

Power plant cooling needs when fulfilled should produce large benefits in all Areas but especially in Areas 2, 3, 6, 9, 15, 17, and 21.

Water quality maintenance should produce the greatest amount of benefits of all needs in the Region. These benefits will be largest in Areas 1, 2, 3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18 and 21.

Costs

Upstream storage costs will be very large in 2020 in Area 15 and relatively large in Areas 7 and 12. These costs will be relatively large in the first planning period in Areas 9 and 14 but will decrease to zero during the rest of the time. Areas 8 and 18 costs for this device will be large during the year 2000 period and Areas 10 and 17 costs will be large during the last period.

The costs of mainstream storage also vary between Areas during the planning period. Areas 17 and 19 costs will be large throughout the planning period, Area 20 costs will be relatively large during the first period, Areas 12 and 14 during the second period, and Area 15 during the third.

Inter-basin transfer costs are large for the year 1980 period in Area 7 and for the 2000 period in Areas 7, 9, 13, 14, and 18. Costs are lower in these Areas during the year 2020 period except in Areas 14 and 18 where costs are higher.

Groundwater development costs will be large in Areas 17 and 19 throughout the planning period, in Area 12 for the first two periods, in Area 18 only during the second period, and in Areas 13 and 15 during the last period.

Desalting costs will be relatively large only in Areas 18 and 21 during the last two planning periods.

Conveyance and treatment costs for publicly supplied water needs will be large throughout the planning period in Areas 15 and 19. These costs will also be large during the first period in Area 21, the second period in Area 10 and the third period in Area 14. Conveyance costs for industrial self-supplied needs will be large in Areas 15 and 18 throughout the planning period. Water conveyance facilities for agriculture irrigation needs will be the largest during the first planning period in Areas 15, 17 and 18, during the second period in Areas 12 and 18, and in Area 1 during the last period. Non-agriculture irrigation needs will have the highest costs for conveyance facilities in Area 15 throughout the planning period. Other Areas will have lower but still large costs for this device Areas 9, 12, 13, 17, and 19 in all periods and Areas 8 and 10 in 2020.

Costs for commercial navigation devices will be large during the entire planning period only in Area 21. These costs will also be large in Areas 14, 15 and 18 during the first period, in Areas 6, 9, 15 and 18 during the second period and in Areas 9 and 20 during the last period. Recreational boating costs will be large only in Area 19 throughout the planning period and also in Areas 18, 16 and 13 during the first, second and third planning periods, respectively.

Power plant cooling costs will be largest in Areas 15 and 17 during the second planning period and in Areas 9, 12, 15 and 17 during the last period.

Water quality maintenance costs will probably be larger than the costs for any other need in the Region and will be large in all 21 Areas. They will be largest in Areas 13 and 14 throughout all planning periods and in Area 15 in 2000 and 2020 for secondary and advanced waste treatment The costs for combined sewer outflows control and acid mine drainage control will be largest in Areas 9, 13 and 14.

LAND MANAGEMENT

The primary concern of this Program is the protection of land and of land associated developments from the actions of water. Thus, it encompasses the needs for flood damage reduction, drainage and erosion control and both structural and managerial devices. It should be noted that this Program concerns itself with catastrophic and rare events such as floods and hurricanes and with continuous and often imperceptible processes such as sheet erosion.

The needs, devices, and costs which comprise this Program are shown on Table 50. They and the benefits from this Program and their relative importance are discussed in the remainder of this section.

Needs

Flood Damage Reduction. Flood damage reduction is considered to be one of the less important needs in the Region. It is considered to be important only in Areas 4, 7, 12, 14 and 15. Upstream flood damage reduction needs will be largest in Areas 9, 17, 18 and 19 throughout the planning period. These needs will grow fastest in Areas 8, 10, 17 and 19. Presently the per capita need is highest in Areas 18 and 20 but this will switch to Areas 6, 7 and 8 by 2020.

Needs for flood damage reduction on major and coastal streams will be largest in Areas 14, 15, 17 and 19 throughout the planning period. They will be largest per capita in Areas 4, 7 and 11 throughout the planning period and grow fastest in Areas 19, 20 and 21.

Flood damage reduction needs from tidal and hurricane flooding will be largest in Areas 9, 10 and 13 throughout the planning period; will be largest per capita in Areas 10, 13 and 16; and will grow fastest in Areas 20 and 21.

Drainage Control. It is thought that drainage control is one of the least important needs in the Region. In no Areas is this considered to be one of the most important needs or a key need. Drainage control in the Report is only of two varieties: cropland and forestland. It is largest for croplands in Areas 11, 17 and 18 throughout the planning period. Cropland drainage control is presently largest per capita in Areas 3, 11, 18 and 20 and in Areas 1, 3 and 11 by 2020. In Areas 1, 2, 3, 4 and 5 this need will grow the fastest.

Forest land drainage control will be largest by 2020 in Areas 11, 17, 20 and 21, and it will be the largest per capita by that time period in Areas 1, 2 and 5. This need will grow fastest in Areas 15, 16 and 17.

Erosion Control. The need for erosion control is considered to be one of the less important ones in the Region. This has been chosen, however, as one of the most important needs for Area 19 and one of the key needs for Area 9. Erosion control needs are of four varieties and include agriculture, urban, streambank and coastal shoreline. Agriculture erosion control needs throughout the planning period will be the largest in Areas 12, 17, 19 and 21. They will grow the fastest in Areas 7, 10 and 18, and largest per capita in Areas 1, 17 and 20.

Urban erosion control needs will be largest in Areas 15 and 17 throughout the planning period. These needs will grow fastest in Areas 10, 18 and 19, and be the largest per capita in Areas 2, 3 and 5.

Table 50
MIXED OBJECTIVE REGIONAL PROGRAM
LAND MANAGEMENT

NEEDS—cumulative		Pres.	1980	2000	2020
Flood Damage Reduction:					
avg. ann. damage, upstream	(m. $)	55	82	145	275
mainstream	(m. $)	80	130	260	530
tidal & hurricane	(m. $)	61	96	181	359
Drainage Control: cropland	(m. acres)	1.2	1.7	2.6	2.8
forest land	(1000 acres)	0	4	142	556
wet land		(1)	(1)	(0)	(0)
Erosion Control: agriculture*	(m. acres)	15	19	22	23
urban and other	(m. acres)	8	11	15	19
stream bank	(1000 mi.)	(21)	0.5	1.5	2.5
coastal shoreline	(1000 mi.)	(12)	0.9	1.9	2.0
DEVICES—incremental		**Purposes**			
Flood Plain Management:					
upstream	(1000 acres)	FDR /	840	1600	520
mainstream		FDR /	(21)	(21)	(21)
Local Flood Protection:					
ocean	(projects)	FDR	11	6	0
river	(projects)	FDR	150	150	50
flood control channels	(mi.)	FDR	810	970	260
Watershed Management	(m. acres)	FDR,Drn /	5.5	7.6	6.7
Erosion Protection: land treatment		Ern	(21)	(21)	(21)
coastal shoreline		Ern,Rec,VC	(12)	(12)	(12)
river shoreline		Ern	(21)	(21)	(21)
Drainage Practices		Drn,FW	(20)	(20)	(20)
Flood Control Storage:					
upstream	(1000 af)	FDR	800	880	510
mainstream	(1000 af)	FDR	430	1030	460
FIRST COSTS—incremental ($ million 1970)					
Flood Damage Reduction: upstream			150	150	80
mainstream			700	650	40
Drainage Control			35	59	28
Erosion Control			2030	2120	870

* Includes cropland, pasture, and forest.
/ Also includes FW, Rec, VC.
( ) Indicates number of basins to which applicable.

Streambank erosion control needs throughout the planning period will be largest in Areas 15, 17 and 19 and largest per capita in Areas 11, 17 and 21. This need will grow most rapidly in Areas 1, 5 and 13.

Coastal shoreline erosion control needs throughout the planning period will be largest and largest per capita in Areas 9, 16 and 18, and grow most rapidly in Areas 6, 13 and 20.

Devices

Upstream Flood Damage Reduction. Watershed management is the most extensively used device for upstream flood damage reduction. This device is considered to be an important device in Areas 9 and 11. It will be used in all Areas except for Areas 1, 2 and 20 in the second planning period, in Areas 15, 18 and 19 in the third period and Areas 13 and 16 in all periods.

Flood plain management and upstream reservoirs are also extensively used throughout the Region. Flood plain management is used slightly only in Areas 1, 2, 13, 16 and 17 and upstream reservoirs are used very little only in Areas 1, 3, 4, 11, 13 and 16. Flood plain management is used more extensively in Areas 3, 4, 6, 8, 10, 11, and 14 while upstream reservoirs more extensively in Areas 2, 5, 8, 9, 10 and 14. The Areas where these devices are used most extensively are, for flood plain management, Areas 5, 7, 9, 15, 18, 19, 20 and 21, and for upstream reservoirs, Areas 6, 7, 12, 15, 17, 18, 19, 20 and 21.

Upstream flood channels will also be used in several Areas. This device will be used to some extent in Areas 8, 11 and 20 and very extensively in Areas 15, 18 and 21.

Mainstream Flood Damage Reduction. Flood plain management will be the most extensively used device for mainstream flood reduction in the NAR. It will be used in all Areas to varying degrees depending upon its local acceptability and effectiveness. These differences are discussed in the Area Programs.

Mainstream reservoir storage for flood damage reduction is a part of the Program in Areas 4, 7, 15 and 17 in small to medium quantities and in Areas 8, 14, 19, 20 and 21 in fairly large quantities.

Local protection from river flooding should be developed in Areas 7, 10, 14 and 15 during the first two planning periods, in Areas 8, 9, 11, 12, 17 and 19 during the first planning period, and in Areas 13 and 21 during the second period.

Even with the use of these three types of devices in the Region, flood insurance is needed, especially in Areas 14 and 15.

Tidal flooding at river mouths is a special problem in several Areas, including 16 and 19, and tidal barriers may be necessary.

Ocean flood protection devices will be generally used along much of the coast of the NAR particularly in Areas 9, 10, 13, 15, 16 and 18.

Drainage Control. Watershed management and drainage practices will be used throughout the NAR, except in Area 13, in all planning periods. Greatest attention to these devices should be given in Areas 11, 17 and 18 for cropland and in Areas 17, 20 and 21 for forestlands.

Erosion Control. Watershed erosion protection devices should be used in all Areas throughout all planning periods. Erosion protection is an important device in Area 9 for coastal shoreline protection. Land erosion protection should be emphasized to a greater extent in Areas 12, 17 and 19 for agriculture, and in Areas 15, 17 and 19 for urban erosion.

Streambank erosion protection devices should be emphasized in Areas 15, 17 and 19.

Devices for coastal shoreline erosion protection should be used in Areas 6, 7, 9, 10, 13, 15, 16, 18, 19, 20 and 21 and emphasized in Areas 9, 16 and 18.

Legal control of urban erosion is especially recommended for use in Area 13 because of the difficulty of using only physical devices.

Benefits

Flood damage reduction needs will receive large benefits only in Area 14.

Drainage control should receive large benefits only in Area 20.

Erosion control benefits should be large in Area 20.

Costs

The flood damage reduction program should not have very large costs in any Area.

The costs for upstream flood prevention will be largest in Areas 15, 20 and 21 in 1980 and in Areas 17, 20 and 21 by 2020. Costs to protect mainstream areas will be largest in Areas 13, 14 and 16.

Drainage control costs will be small. They will be largest in Areas 11, 17 and 18 during the first two planning periods and largest in Area 11 by 2020.

Erosion control costs will be very large throughout the planning period in Area 9 for its coastal shorelines protection and large in Areas 10, 15, 17, 18 and 19 throughout the planning period.

ENVIRONMENTAL MANAGEMENT

This Program encompasses four needs: Water Recreation, Fish and Wildlife, Health and the Visual and Cultural Environment. Most of these needs are hard to place in any one category although they generally require land and water resources in close association. Fishing, for instance, requires land for the fisherman's access to the water. Devices for these needs can only succeed if they are applied to both resources. These needs often are in the position of having to be protected from the other Program devices. Once the other Programs physically take away or degrade a fishing area or landscape it generally cannot be brought back.

This Program's needs, devices and costs are shown in Table 51, and described in the following section.

Needs

Water Recreation. Water recreation is one of the most important needs in the NAR. In relationship to other needs of each Area, water recreation is considered to be one of the most important needs in thirteen Areas that include 1, 2, 4, 5, 7, 8, 9, 10, 13, 14, 15, 17 and 20. There are six measures of water recreation needs in this Study including visitor days, stream or river miles, water surface, beaches, pools and land facilities.

Table 51
MIXED OBJECTIVE REGIONAL PROGRAM
ENVIRONMENTAL MANAGEMENT

NEEDS—cumulative		Pres.	1980	2000	2020
Water Recreation: visitor days	(m.)	(21)	930	1480	2440
Fish & Wildlife: sport fishing man-days	(m.)	100	110	140	180
hunting man-days	(m.)	38	43	54	66
nature study man-days	(m.)	60	70	88	109
Health: vector control and pollution control		(21)	(21)	(21)	(21)
Visual and Cultural:					
landscape maintenance					
unique natural	(1000 sq. mi.)	11	26	26	26
unique shoreline	(mi.)	90	1360	1360	1360
high quality	(1000 sq. mi.)	4	12	19	26
diversity	(1000 sq. mi.)	(10)	3.7	7.2	10.2
landscape development					
quality	(1000 sq. mi.)	(6)	0.9	1.9	2.8
metro. amenities	(mi.)	(1)	2	2	2
metro. amenities	(1000 sq. mi.)	(12)	0.66	0.67	0.67

DEVICES—incremental		Purposes			
Land Controls:					
fee simple purchase (buying)	(sq. mi.)	VC,FW,Rec	17200	2700	2600
fee simple purchase (buying)	(mi.)	VC,FW,Rec	990	0	0
purchase lease	(sq. mi.)	VC,FW,Rec	2840	360	350
easements	(sq. mi.)	VC,FW,Rec	3600	3300	3100
deed restrictions		VC,FW	(1)	(1)	(1)
tax incentive subsidy	(sq. mi.)	VC,FW	700	450	300
zoning	(sq. mi.)	VC,FW,Rec	4830	450	300
zoning	(mi.)	VC,FW,Rec	260	0	0
zoning and/or tax inc. subs.	(sq. mi.)	VC,FW,Rec	7700	3600	3200
zoning and/or tax inc. subs.	(mi.)	VC,FW	32	0	0
Facilities:					
recreation development		Rec	(21)	(21)	(21)
overland transportation to facility		Rec	(17)	(17)	(17)
parking and trails		FW,VC,Rec	(21)	(21)	(21)
site sanitation and utilities		VC,Rec	(21)	(19)	(19)
Biological:					
habitat management, fish		FW	(21)	(21)	(21)
wildlife		FW	(21)	(21)	(21)
fishways		FW	(12)	(12)	(12)
stocking, fish		FW	(16)	(16)	(16)
wildlife		FW	(19)	(19)	(19)
insect control		Hlth,Rec	(21)	(21)	(21)

FIRST COSTS—incremental ($ million 1970)			
Visual and Cultural	6500	1200	1200
Water Recreation	6200	4300	6300
Fish and Wildlife: fishing*	64	86	102

* Includes annual operations and maintenance costs.
( ) Indicates number of basins to which applicable.

Certain Areas of the Region are consistently among those with the largest, largest per capita and fastest growth rates of each of the varieties of water recreation needs. Areas 8, 9, 10, 12, 15 and 17 consistently appear among those with the largest of all types of water recreation needs throughout the planning period. Areas 13, 14 and 15 also have large visitor day needs throughout the planning period. Areas 2, 3, 4, 5, 6, and 8 consistently appear among those with the largest per capita needs, except for visitor days, and Areas 12, 16 and 19 among those with the highest growth rates. Areas 5, 6 and 7 have the highest visitor day needs.

Additional Areas with high growth rates of water recreation needs include Area 7 for beaches; Area 17 for land facilities; and Area 20 for available stream and river miles and water surface.

Fish and Wildlife. The various types of fish and wildlife needs are considered among the most important in the Region. They are considered to be one of the important needs in eight Areas including: 1, 4, 5, 7, 8, 14, 15 and 20. They are considered a key to the achievement of other needs only in Area 9. There are eleven measures of fish and wildlife needs and included among them are man-days; lake and stream surfaces; and access for fresh, salt and anadromous fishing, for hunting and for nature study. The Areas that have the largest of all types of man-day needs for fish and wildlife are 9, 13, 15, 17 and 19. The need for man-days for fishing and nature study activities are largest in Areas 9, 13, 15 and 19 and largest for hunting in Areas 15, 17 and 19.

Areas 3, 4, 5 and 6 have the largest per capita needs for fishing man-days; Areas 1, 2, 11, and 20 have the largest per capita needs for hunting man-days; and most Areas have the same per capita needs for nature study.

Areas with the fastest growth rates for all fish and wildlife man-day needs include 10, 18, 19 and 20. Fishing man-day needs grow fastest in Areas 10, 18, 19 and 20 and hunting and other activity man-day needs grow fastest in Areas 8, 19 and 20.

Health. Health programs as part of water resources development are considered to be one of the least important needs in the NAR even though specific types of health needs – water quality, vector control and environmental health – appear throughout the Region. Health needs occur continuously so that the use of preventive devices is the best guarantee of their being fulfilled.

Sanitary waters for recreation and shellfish, elimination of encephalitis, treatment of public water supplies and reduction of recreation disturbing mosquitoes, horse flies and biting midges are the more important health needs that appear throughout the NAR. Creating sanitary conditions for shellfish is a large need in Areas 5, 6, 7, 8, 9, 10, 13, 18 and 21. The reduction of insects will be a large need to help fulfill water recreation needs in Areas 1, 17 and 18. Control of jellyfish is a need in Area 18 to aid water recreation.

Visual and Cultural Environment. Visual and cultural needs are among the most important in the Region. It is considered an important need in Areas 2, 3, 4, 5, 7, 8, 11, 13, 18 and 19. It is considered a key need in Areas 1, 4, 13, 14, 18 and 19. There are nine varieties of visual and cultural needs in this Study.

These varieties include maintenance of various types of landscapes such as unique natural, unique shoreline, high quality, diverse and agricultural, and development of landscapes with metropolitan amenities, quality and diversity.

Areas 11, 12, 15 and 19 have the largest over-all needs for landscape maintenance. All four Areas have large needs for maintenance of agriculture landscape; Areas 12 and 19 need maintenance of landscape diversity; Area 12 needs maintenance of high quality landscape; Area 19 needs maintenance of unique shorelines; and Areas 11 and 12 need maintenance of unique natural landscape.

Many other Areas have large needs for landscape maintenance although on a lesser scale than Areas 11, 12, 15 and 19. Area 1 has a large need for maintenance of unique natural landscapes. Area 5 and 18 have large needs for unique shoreline maintenance, and Areas 2 and 3 for maintenance of high quality landscapes. The need for maintenance of diverse landscapes is also large in Area 20.

Areas 9, 10, 14 and 17 have the largest over-all need for landscape development. Areas 13 and 15 also need development of metropolitan amenities; and Area 18 also needs development of quality landscape.

Devices

Water Recreation. Changing of project design loads should be the devices used in the largest number of NAR Areas. Only in Areas 1, 4 and 20 is the changing of project design loads not used. Additional overland transportation to water recreation facilities are included for all planning periods and all Areas except for 1, 2, 4, 5 and 6. Development of recreation facilities is important to fulfillment of the water recreation need in Area 11.

The addition of recreation as a new use of a project should be accomplished in all Areas except 1, 2, 3, 4, 12, 13, 16 and 18 in all planning periods.

Additional reservoirs for new water surfaces should be obtained in Areas 4, 7, 8, 9, 10, 14, 15, 17, 19, 20 and 21 in all planning periods. Coastal shoreline erosion protection is needed in Areas 6, 9, 10, 13, 15, 16, 17 and 21. New water recreation site facilities should be added throughout the Region, but especially in Areas 3, 5, 6, 7 and 18.

Other devices should be used in Areas with special recreation problems. Insect control will be important to the fulfillment of water recreation needs in Area 1. Streambank erosion protection will most likely be needed in Area 6. Power plant cooling waters will be available for use in Areas 9, 13 and 16 for heated swimming and extension of the recreation season. Flood plain management, waterfront renewal and metropolitan amenities have been pointed out as devices of other needs that would help water recreation needs especially in Area 14. Similarly, land acquisition, protection from jelly fish, and parking and trails will also be helpful in meeting water recreation needs, especially in Area 18.

Fish and Wildlife. Several devices for fish and wildlife needs should be in all Areas and planning periods. These include fish and wildlife habitat management, enforcement of water quality standards, land acquisition and parking and trails. Habitat management has been pointed out as a key device in Area 11, and an important device in Areas 9 and 11. Small game stocking should be used in all Areas except for 1 and 21 and fish stocking used in all Areas except for 1, 2, 4, 5 and 18.

Migratory fish can be aided in many Areas of the NAR and existing water management projects will have to be removed or modified in most of these Areas except for 11, 12, 13, 15, 16, 18 and 20, for this to be accomplished. Fishways will also be necessary in many Areas to aid the migratory species and this includes Areas 1, 2, 3, 5, 6, 7, 8, 9, 10, 17, 19 and 21 in all planning periods.

Access, parking and trails should be used in all Areas for fish and wildlife needs.

Fish and wildlife needs should be added as a purpose for existing projects in Areas 8, 9, 10, 13, 14, 15, 18, 19 and 21 in all planning periods; in Area 17 during the last two planning periods; and in Area 20 during the last period.

New reservoirs will be needed for fish and wildlife needs in Areas 8, 9, 10, 14, 15, 16, 18, 19, 20 and 21 for all planning periods. This device will be needed in Area 17 during the last period.

Health. Insect control is recommended for all Areas of the NAR but is important in Area 1 where mosquitoes and black flies interfere with water recreation needs.

Monitoring of pollution should be carried on throughout the Region.

Shellfish sanitation requires special attention in Areas 6, 7, 8, 10, 13, 18 and 20 so that they will remain or can become edible. Sea oysters need protection in Area 21.

Area 9 should have increased control of marine oil spills. Swimming water monitoring should be increased in this Area. Area 11 should have increased control of well water supply sources to obtain more completely healthy water supplies. Legal control of discharges into ground water is recommended for Area 12.

Health needs in Area 13 should be met by elimination of septic tanks and the cleaning up of swimming beaches. Area 16 should have increased control of sharks and encephalitis protection for the health of swimmers. Area 18 also needs more protection for swimmers from jelly fish.

Visual and Cultural Environment. Fee simple purchases, easements, and tax incentive subsidies and zoning should be the most widely used devices in the Region for visual and cultural needs.

Land controls are considered to be key devices in Area 4 and important devices in Areas 1, 2, 4, 9 and 18.

Fee simple purchases should be largest in Areas 1, 2, 8, 11, 17, and 19; fairly large in Areas 3, 5, 9, 12, 15, 18 and 20; fairly small in Areas 6, 7, 10, 13, 14, 16 and 21; and none in Area 4.

Easements will probably be largest in Areas 2, 3, 12, 15, and 19; fairly large in Areas 6, 8, 11, 17, 18 and 20; smallest in Areas 7, 10, 13, and 14; and none in Areas 1, 4, 5, 9, 16 and 21.

The use of zoning and/or tax incentives should be largest in Areas 4 and 12; next largest in 2, 3, 6, 15 and 20; smallest in Areas 7 and 8; and none in the other Areas. Zoning itself should be largest in Areas 1, 5 and 11, small in Areas 9, 16 and 18; and none in the remaining Areas.

Purchase leases should be used in Areas 10, 15, 16 and 18 but should be used to the greatest extent in Area 19.

Deed restrictions are recommended for use in Area 15 to maintain open spaces.

New reservoirs should be provided for scenic diversity in Areas 2, 7, 9, 10, 14, 16 and 18 in all time periods and in Areas 12, 13, 15, 17, 19 and 21 during the first time period. These should be multiple use reservoirs of all types such as with water supply, flood control, and power generation, and the Program for water development needs should fulfill these visual and cultural needs.

Waste treatment to meet minimum water quality standards should be supplied in Areas 7, 8, 9, 10, 12, 13, 14, 16,17, 18, 19 and 20 during the first planning period, in Area 15 during the first two periods; in Area 21 throughout all periods. This treatment would provide minimum amounts of high visual quality landscape in these Areas.

Flood plain and watershed management should be provided throughout most of the Region. This would also be a multiple use of these devices as they help meet flood damage reduction needs. Only three Areas do not need both of these devices for visual and cultural needs for all years. Flood plain management is needed only in the first planning period for Areas 1, 13 and 21. Watershed management is not needed at all in Area 1 and only in the first period for Area 13.

Other special devices should be used sporadically in the Region for visual and cultural needs. Debris removal should be used in Areas 12 and 13. Water front rehabilitation should be used in Area 13. Shoreline and beach protection is included in Area 16. Access, parking and trails should be provided in Area 20.

Benefits

Water recreation benefits will probably be large in Areas 2, 4, 5, 6, 8, 15, 16, 17, 18 and 19.

Fish and wildlife benefits should be large in Areas 2, 5, 8, 15, 16, 17 and 18.

Health benefits will probably not be large in any Area.

Visual and cultural needs should receive large benefits throughout the Region but they will be particularly large in Areas 2, 5, 8, 12, 15, 16, 17, 18 and 19.

Costs

The costs for water recreation land facilities will be largest in Areas 8, 9, 10, 12 and 17 in the first planning period and largest in Areas 8, 9, 10, 12, 13, 14, 15 and 17 in the second and third periods.

Fishing access costs for fish and wildlife needs will be largest in Areas 13 and 19 throughout the planning period.

Land control costs for the maintenance or enhancement of the visual and cultural environment will be very large throughout the Region especially during the first planning period. Areas 8, 9, 10, 15, 18 and 19 will have the highest costs for this need throughout the planning period. Added to these Areas with high costs will be Areas 13 and 17 in 1980 and Areas 12 and 14 in 2000 and 2020.

IMPLEMENTATION OF REGIONAL PROGRAM

A program is only valuable if it is a step toward action. To move towards action in the NAR, existing plans and programs, and institutional, fiscal and technical problems must be considered.

Existing Programs and Plans

There is a multitude of programs ongoing within the NAR Region administered by Federal, state and local agencies and by private organizations that directly or indirectly affect the water and related land resources. The cumulative effects of all the programs are reflected in the general trend of the economic activities and the utilization of resources. This trend forms the basis for projections in the NAR Study and, therefore, there is the implicit assumption that these programs continue. Specifically, major water resources projects now under construction or funded for construction are considered part of the ongoing programs and as part of the base from which programs developed in this Study begin.

Completed major planning efforts, such as the Susquehanna River Basin Study, the Connecticut River Basin Study or the Comprehensive Plan for the Delaware River Basin, have been completed in recent years on areas lying wholly within the NAR boundaries. These basin plans propose specific projects and are based on specific detailed data and on assumptions and objectives that may be at variance with those used in the NAR Study. The early action programs recommended in these plans represent the best available specific action-oriented planning for these areas. The NAR program is sufficiently broad, however, so that implementation of the basin plan recommendations will fall within the NAR framework as the programs developed in the detailed plans are generally smaller. Differences between the NAR Program and the programs of these three other major planning efforts are described in Annex 1 to the Report. Explanations are given for the major differences when they are known.

Institutions

Federal agencies, state agencies of 13 states and the District of Columbia and innumerable local agencies plan and operate in the water and related land resources field. Regional planning agencies, River Basin Commissions, Coordinating Committees and special purpose regional organizations coordinate activities on the localized level while State Water Resources Boards and similar groups and the Water Resources Council perform this service on state and National levels. The strength of the regional organizations has grown in the last years and they, together with the state and Federal agencies, represent the best hope for coordination of activities. No permanent agency exists that covers all activities in the entire NAR Region. A major problem may well emerge from the great differences in staff capabilities that exist between states and different regional and local agencies.

Statutory law, case law and policies vary from state to state, area to area. In many cases today's needs have made many laws and policies inadequate. This is particularly true in relation to resource allocation and land use policies such as flood plain management. Similarly, great differences exist between Federal agencies.

Continuous coordination, strong leadership and possible redefinition of roles are needed.

Fiscal

In addition to the costs themselves, the determination of who pays is a vital part in the Program's implementation. Present cost sharing policies vary widely and gross assumptions have to be used to arrive at an approximate estimate of Federal and non-Federal costs of the Regional Program. Federal shares for planning vary from 100 percent for Water Resources Planning to 50 percent for Water Pollution Control Comprehensive Basin Planning. In construction, Federal shares vary from 100 percent for Flood Control Reservoirs to 50 percent for Recreation Development on Federal projects and to only pre-financing for Water Supply Storage. Furthermore, the rules of cost sharing are changing with the general trend being an increase in the Federal share.

When discussing Federal and non-Federal shares for a program like the NAR's it must be considered that these cost sharing formulas are not directly applicable because many multiple purpose portions of the program would be based on several formulas. For instance, on a reservoir, flood control storage would be all Federal while the part for recreation would be 50 percent Federal and the part for water supply completely non-Federal. Federal and non-Federal cost estimates are shown for the NAR Regional Program in Table 5.2 along with the percentages used to determine the shares. These estimates do not represent existing policy or cost sharing formulas but are estimates of how program costs might be distributed taking into consideration both existing formulas and trends of changes in these formulas.

Technical

Before a program based on framework analyses can be put into action several steps must be taken to develop plans ready for implementation. These plans take time and manpower to prepare and therefore have a significant cost. Three types of planning programs appear needed. The first type are programs that plan for a specific need in the entire region. This type is called for when a need appears key, important or large in all or in at least most Areas. The second type is the river basin study. It is appropriate in Areas where many and interrelated needs appear large or important. Project studies, the third type, are required in all cases where specific devices can meet a specific need relatively independent of other devices and needs, and the framework study is sufficient to define the interrelations. Traditionally, planning studies have cost 1/2 to 1 percent of the total program costs. With programs of the magnitude of those discussed here 1/2 to 1 percent is a very large number and the availability of qualified planning personnel to carry out the in-depth planning program may be a serious problem in the future.

Engineering, Administration and Supervision or its equivalent in non-structural portions of programs is the final step in implementation. These costs, estimated from 5 to 20 percent of program costs depending on the specific portion of a program, are generally included in the over-all cost estimates.

TABLE 52
ESTIMATED FEDERAL/NON-FEDERAL
COSTS AND COST SHARES FOR
NAR PROGRAM, 1980-2020

	FIRST COSTS ($ million 1970) FEDERAL			NON-FEDERAL			SHARES IN PERCENT	
	1980	2000	2020	1980	2000	2020	Federal	Non-Federal
PROGRAM FOR WATER MANAGEMENT								
Water Development Costs:								
storage, upstream	102	108	300	68	72	200	60	40
mainstream	114	222	432	76	148	288	60	40
wells	0	0	0	210	220	140	0	100
desalting	0	0	0	38	458	436	40	60
Water Distribution Costs:								
inter-basin transfers	9	253	177	14	379	265	40	60
public water supply	0	0	0	380	1,080	1,450	25	75
industrial self-supplied water	0	0	0	29	53	81	0	100
irrigation, agriculture	0	0	0	60	57	18	0	100
nonagriculture	0	0	0	150	140	190	0	100
Navigation: commercial	1,240	1,200	880	0	0	0	100	0
recreational	33.5	68	84	33.5	68	84	50	50
Power Plant Cooling Water	0	0	0	0	590	1,660	0	100
Water Quality Maint.								
waste treatment, secondary	6,050	13,750	26,400	4,950	11,250	21,600	55	45
advanced	545	1,975	3,658	445	1,615	2,992	55	45
other [1]	4,345	0	0	3,555	0	0	55	45
PROGRAM FOR LAND MANAGEMENT								
Flood Damage Reduction: upstream	128	112	90	42	38	30	75	25
mainstream	540	645	0	180	215	0	75	25
Drainage Control	14	24	12	21	36	17	40	60
Erosion Control	1,025	1,070	440	1,025	1,070	440	40	60
PROGRAM FOR ENVIRONMENTAL MANAGEMENT								
Visual and Cultural	0	0	0	6,500	1,200	1,200	0	100
Water Recreation	3,100	2,200	3,150	3,100	2,200	3,150	50	50
Fish and Wildlife: fishing	32	43	51	32	43	51	50	50

1. Combined sewer overflows control and acid mine drainage control.

CHAPTER 9

DISCUSSION AND CONCLUSIONS

This Chapter presents the findings of the Coordinating Committee. These findings, arranged in four sections, are based on the Regional and Area Programs (Annexes 1 and 2) and the supporting material found in the Appendices. The four sections are

General Findings
Program Summaries
Geographical Summaries
Program Implications

The first section presents the general findings and includes estimates of the adequacy of Regional water resources and the ability of the recommended Program to meet the needs and objectives of water management in the Region.

Highlights of the Water, Land and Environmental Management Programs are presented in the Program Summaries section. Included here are summaries of those planning elements which are largest, fastest growing, important and key as they appear in the three Management Programs presented in Chapter 8.

The Geographical Summaries section contains highlights of the Programs as they relate to geographic distribution of problems in the Region, Areas and Special Patterns. These geographic problems concern: resource transfers to meet needs, effects of the Programs on areas outside of the Region and patterns of Program elements (objectives, needs, devices, benefits and costs) within the Region.

The Program Implications section summarizes General Problems and Deficiencies of the NAR Program and describes Conflicts that would result from implementation of the Program.

GENERAL FINDINGS

The Coordinating Committee found that if the resource management programs outlined in this Study are generally followed and if the assumptions underlying the Study are proven accurate, the water and related land resources in the North Atlantic Region will be adequate to provide the services required by the Region's people through the year 2020 and beyond.

Large increases in the services supplied by water resources and required by the Region's people, however, cannot be continuously fulfilled by the customary means of increasing natural resource consumption and use. Provision of services solely through development of natural resources must cease because the magnitudes and rates of increase in needs have become very large, the practical limits of resource development are being approached, the monetary and natural resource investments to meet these needs have become excessive, and the quality of life has become impaired. It is imperative that research, studies and programs be initiated now to find and implement means of reducing the needs for water and related land resources. This reduction of needs must occur no matter which objective is being sought although the degree of need control versus resource use does vary to some extent according to the objective In those Areas, for instance, where Environmental Quality objectives are stressed, need control should be more actively sought because of the environmental effects of development projects.

The various objectives expressed in the Area Programs can be achieved with the greatest net benefits and a minimum of conflict only if a full range of management techniques are used – including resource development, technological changes and need regulation – in the Program developed by the Coordinating Committee. The recognition in this Program of multiple objectives and of the increasing complexity of resource management requires increasingly precise and accurate decision making and negotiating procedures. These procedures require the development of means for measuring the changes brought about in resources and in peoples' values. Once these measurements are possible, more accurate trade offs can be made (between development and preservationist objectives, for instance) during decision making and negotiation procedures.

The Coordinating Committee also found that land use planning and management is essential for successful water resources management. Land use planning and management must include controls on the type, extent and distribution of water related land uses. Successful planning for both resources requires that conflicts between water and land uses are resolved through extensive coordination among the responsible agencies.

Finally, the Committee found that a comprehensive viewpoint must be maintained in all studies, plans and management actions that affect water and related land resources even when these activities are concerned with only one purpose. This approach will allow the consideration at all decision levels of the interactions between the planning elements and of the implications of choosing among alternative programs.

Programs and recommendations of the NAR Study should lead to more detailed studies at the Federal, state and local levels which in turn lead to implementation. Agencies at these government levels can cite aspects of the NAR Study, such as the Area Programs in Annex 1 or the highlights of the Programs in the next sections, when making budget requests for studies and programs.

PROGRAM SUMMARIES

Water Management

Needs. Needs of this Program vary a great deal in their importance to the Region. Water quality maintenance needs are the most important in this Program. This need will grow very rapidly and must be fulfilled throughout the 21 Areas. It is important to the mixed objectives of fourteen Areas (2, 4, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19) and key to the fulfillment of other needs in sixteen Areas (1, 2, 3, 4, 5, 7, 8, 9, 12, 13, 15, 16, 17, 18, 19, 21) Water quality maintenance is most often key to the fulfillment of visual and cultural, fish and wildlife and water recreation needs, and is almost as often the key to the fulfillment of publicly supplied and industrial self-supplied water needs.

Areas with large water quality maintenance needs include Southeastern New York Metropolitan Area (13), Northern New Jersey (14) and, Delaware River Basin (15).

Water quality maintenance needs will grow most rapidly in the Delaware River Basin (15), the Rappahannock and York River Basins (20) and the James River Basin (21). This need will be the largest per capita in the St. John (1) and the Pennobscot River Basins (2).

Publicly supplied and industrial self-supplied water needs are among the most important throughout the Region. Each of these two needs is felt to be important to the mixed objectives of fourteen Areas and is central to the attainment of the National Income and Regional Development objectives in all Areas. Both needs are important to the mixed objectives of Areas 1, 3, 4, 5, 6, 9, 10, 11, 12, 15, 16, 17 and 20. Only publicly supplied water is important in Areas 13,14 and 19 and only industrial self-supplied water in Areas 2 and 21. These water needs will grow as the Region's population and industrial productivity grow. The need for publicly supplied water is a key need in Southeastern New York Metropolitan Area (13) as it will help the fulfillment of the other needs of the Area. The need for industrial self-supplied water will grow very rapidly, passing that of publicly supplied water during the 1980-2000 planning period.

Power plant cooling needs are also among the most important of the Region especially to the achievement of the mixed objectives of Areas 4, 5, 6, 9 and 21. A large amount of water will be used to satisfy this need. Its growth rate will be extremely high especially for withdrawal of saline water and consumption of fresh water.

Large power plant cooling needs for fresh water appear in the Connecticut River Basin (8), the Hudson River Basin (12), the Delaware River Basin (15), the Susquehanna River Basin (17), the Potomac River Basin (19), and the James River Basin (21).

The other needs of this Program are of less importance. Hydroelectric power generation is among the least important needs in terms of water use although it is essential for serving the peak portion of power demands. Several of this Program's needs will grow rapidly, however, including hydroelectric power generation which grows very rapidly as the demand for peaking power increases in the Region. Agriculture irrigation water needs will grow rapidly as the industry tries to remain efficient to compete with other agricultural areas of the Nation. Irrigation will also help attain landscape diversity in many parts of the Region. Non-agriculture irrigation needs will grow very rapidly in response to increased use of golf courses and industrial parks.

Commercial navigation and recreational boating needs are of less importance in the Region but will be locally important because of their large impacts on local economies and environments, especially localities with good harbors and ports such as Boston, New York, Philadelphia, Baltimore and Norfolk. Both needs will grow rapidly.

Devices. Water quality maintenance devices are considered to be important to the fulfillment of the needs of fifteen Areas of the Region (1, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18 and 19) and are the most important devices of this Program. The needs that these devices help fulfill include publicly supplied water, industrial self-supplied water, irrigation water, power plant cooling, water recreation, fish and wildlife and visual and cultural. The primary devices are secondary and advanced waste treatment plants, monitoring facilities, acid mine drainage control, stormwater discharge control and separation of combined sewers. These devices are also key to the success of devices for other needs in five Areas (3, 4, 9, 13 and 15). Cooling towers and ponds are the primary devices for power plant cooling. These devices are important to fulfillment of needs in three Areas (8, 15 and 17).

Research will be very important for the devices of this Program. Coordination of this research, however, will be increasingly important as many diverse problems and solutions are of concern. Priorities must be assigned to all of these problems and to the various approaches to research, duplications and omissions must be found.

Reservoir storage is also considered to be an important device for this Water Management Program especially to the fulfillment of the needs in Areas 8, 10, 12, 14, 15 and 17. Almost as important are withdrawal devices in Areas 7, 12, 14, 15 and 17 and conveyance devices, including those for inter-basin transfers, in Areas 8, 9, 12, and 13. All of these devices are particularly important in helping fulfill the needs of publicly supplied water and industrial self-supplied water. These devices are sometimes considered to be important in helping fulfill the needs of irrigation water and power plant cooling.

Wells are of less importance to this program (being considered important to fulfillment of needs only in Area 15 and in some portions of other Areas) although rural water supply needs and the water withdrawal needs of Long Island (sub-area 13b) are almost entirely dependent upon this device as are some irrigation needs. Pump storage is of least importance to this Program.

While desalting is projected to be the fastest growing source of water, it is currently of no significance in the NAR. The total quantity of desalted water will be small even in the year 2020, and significant for water development only in the Delmarva Peninsula (18) and the James River Basin (21). Ground water will be the next fastest growing source of water and will be increasingly significant in those portions of the Region where it can meet enough of the local needs as to reduce the use of more expensive devices (such as in parts of Areas 13, 16, 18 and 21). Upstream and mainstream reservoirs will be next in growth rates while inter-basin transfers will grow the least.

Presently, the Areas with the lowest per capita quantities of available water are Southeastern New England (9), Southeastern New York Metropolitan Area (13), Northern New Jersey (14) and the Chesapeake Bay and Delmarva Peninsula Drainage (18).

Benefits. Fulfillment of this Program's needs will produce very large benefits throughout the Region. The largest benefits of this Program will be produced by fulfillment of the water quality maintenance needs. Large benefits from water quality maintenance will occur in 17 Areas of the Region (not in Areas 5, 11, 19 and 20) which is far more than the number of Areas benefiting from fulfillment of any other need. Benefits will be large in seven Areas (2, 3, 6, 9, 15, 17 and 21) from the fulfillment of the power plant cooling need.

Benefits from the other devices of this Program will be large throughout the Region, especially from fulfillment of the publicly supplied and industrial self-supplied water needs. Fulfillment of commercial navigation and recreational boating needs will provide several Areas with large benefits (Areas 5, 10, 15, 18 and 21, and Area 16, respectively.)

Costs. Program costs for water quality maintenance will be very large for the Region. Water quality maintenance has the largest costs in every Area. Only during single planning periods are any of the other costs higher. Southeastern New York Metropolitan Area (13), Northern New Jersey (14) and the Delaware River Basin (15) will have the largest costs for water quality maintenance. Power plant cooling costs will grow rapidly and will be largest for Areas 12, 15 northern part of the Region (Areas 1 through and 17). Power plant cooling costs are given only for those additional cooling facilities that are used beyond the National Income objective.

Water supply costs will be fairly large. Water withdrawal and conveyance costs will be the largest device costs for water supply, especially for the publicly supplied water need. Costs will grow very fast for upstream reservoir storage during the last time frame and for water withdrawal and conveyance for publicly supplied water needs during the second time period. As needs become lower there will be decreases in total costs for wells during the last time period and for agriculture irrigation and commercial navigation throughout the 50 year period.

Major reservoir storage costs are relatively low during the 1980 planning period as the cost for several large projects recently completed, now under construction or funded, such as Beltzville and Tocks Island (15), Raystown (17), and Gathright (21), are not included in the costs of the Water Resources Development Program.

Land Management

Needs. Flood damage reduction and erosion control are among the less important needs in the Region. Drainage control needs are among the least important. Flood damage reduction needs will be largest for upstream damages in Areas 9, 17, 18 and 19, for mainstream damages in Areas 14, 15, 17 and 19, and for tidal and hurricane damages in Areas 9, 10, 13 and 18. The need for flood damage reduction is considered to be important to the mixed objectives in five Areas (4, 7, 12, 14 and 15) and it has a fairly rapid growth rate. Much attention has been given to this need for many years but there are still Areas with local problems.

Two locations with critical flood damage problems are the Passaic River Basin in Area 14, Northern New Jersey, which has large potential mainstream flood damages and New York City (in Area 13) which has large potential tidal and hurricane flood damages.

Erosion and drainage control needs will grow fairly slowly during the planning period except for stream bank erosion control needs which grow fairly rapidly. Coastal shoreline erosion control needs are potentially critical especially along those coastlines which have heavy recreation use and urban development.

Devices. Erosion protection devices for coastal shoreline erosion control needs are key in Southeastern New England (9) where the success of the devices for the Area's large water recreation needs depend upon retention of the very complex coastlines.

The full effect of some of the devices for coastal shoreline erosion control and tidal and hurricane flood damage reduction is not fully understood and should be studied. These devices are particularly a problem in Areas 9, 13 and 18. Watershed management is an important device in two Areas (9 and 11) for fulfillment of flood damage reduction and drainage control needs.

Flood damage reduction will increasingly depend upon flood plain management in most portions of the Region. The various aspects of this device -- education, zoning, flood warnings, flood proofing, etc. -- are not fully integrated nor accepted by the public (i. e., zoning) so that local management of this program should be improved. Such improvements, however, will be difficult without increased state participation since conflicts over methods of control commonly bring local flood plain management programs to a standstill.

Benefits. The benefits from this program will be moderately large. The fulfillment of flood damage reduction needs will produce large benefits in Northern New Jersey (14), drainage control benefits will be large in the Rappahannock and York River Basins (20), and erosion control benefits will be large in the Rappahannock and York River Basins (20).

Costs. This Program's costs are fairly large but they will decrease after the second planning period. The costs of the flood damage reduction program will be large especially in Southeastern New England (9) for shoreline coastal protection. Mainstream flood damage reduction costs will also be large but will decrease as flood plain management becomes the primary means of control.

Environmental Management

Needs. Visual and cultural environment, water recreation and fish and wildlife needs of this Program are among the most important of the Region. Visual and cultural environment needs are very large during the first planning period as landscapes are to be preserved while costs are still relatively low. Water recreation needs grow fairly rapidly while the growth rate of the fish and wildlife needs will be fairly low. In this Region, health needs, other than water quality maintenance, are among the least important to a water-related program.

Achieving the mixed objectives of ten Areas (2, 3, 4, 5, 7, 8, 11, 13, 18 and 19) depends upon visual and cultural environment as an important need. This is also a key need in six Areas (1, 4, 13, 14, 18 and 19) as it will primarily aid in fulfilling the water recreation, fish and wildlife and health needs.

Most Areas have at least one type of visual and cultural need that is large. The northern Areas -- 1, 2, 3, 4, 5, 6, 8 and 11 -- have large needs for all types of landscape maintenance and development. The large visual and cultural needs of the southern Areas of the Region vary greatly between these two types even within each Area. The Hudson River Basin (12), however, has large needs for every type of landscape maintenance and development.

Water recreation is an important need in 13 Areas (1, 2, 4, 5, 7, 8, 9, 10, 13, 14, 15, 17 and 20) and fish and wildlife in 8 Areas (1, 4, 5, 7, 8, 14, 15 and 20). Fish and wildlife needs are key in one Area (9) to fulfillment of the visual and cultural need.

Water recreation and fish and wildlife needs are largest in the Southeastern New York Metropolitan Area (13) and the Delaware River Basin (15). These needs are almost as large in Southeastern New England (9) and the Potomac River Basin (19). Only the Potomac River Basin (19) of these four Areas can supply its own needs while the needs of the other three Areas will exert pressure on the water resources of neighboring Areas.

Devices. Land control is the most important device for the needs of this Program. This device is considered to be important to the fulfillment of the needs in five Areas (1, 2, 4, 9 and 18) and key to the success of other devices in one Area (4). The use of land control is of particular importance in these Areas to the fish and wildlife and visual and cultural needs. This device is often difficult to use because of public resistance to purchase of private lands for public purposes or to strict zoning and other control procedures.

Widespread use is made of land facilities and biological management throughout the Region. There will be increasing controversies over the use of these devices in the Region. The public will become increasingly sensitive to new technical problems, such as the procedures for managing wildlife that have overpopulated an area or the decisions for locating new trails, boating facilities or modern camping facilities such as electricity.

Insect control is important in Area 1 for fulfilling the need of water recreation. This device will be a problem in the future due to the controversy over the use of pesticides.

Habitat management is a key device in one Area (11) for the success of other fish and wildlife devices and important in two Areas (9 and 11) for the fulfillment of the water recreation and visual and cultural needs.

Benefits. Benefits from this Program will generally be very large. Areas where these benefits will be large include ten for water recreation (2, 4, 5, 6, 8, 15, 16, 17, 18 and 19), seven for fish and wildlife (2, 5, 8, 15, 16, 17 and 18) and nine for visual and cultural (2, 5, 8, 12, 15, 16, 17, 18 and 19). All of these benefits, including those for the health needs, are very difficult to measure and evaluate. A great deal of research is necessary to determine what people desire for this Program and what procedures are best for the various publics. There is a large variety of very often conflicting public desires expressed over this Program.

Costs. Costs for this Program will be very large. In some Areas, during individual time periods, this Program's costs will be extremely large. Costs will be largest in Southeastern New York Metropolitan Area (13) and Delaware River Basin (15). Visual and cultural environment costs will be largest during the first planning period as land control should be attained as soon as possible. At present there exists no unified program of land management to fulfill the visual and cultural needs. New and reoriented policies, regulations and programs are necessary. Water recreation costs are very large from the present to 1980 as devices will be provided to fulfill presently unmet needs in addition to those in the future.

GEOGRAPHICAL SUMMARIES

North Atlantic Region

Water quality maintenance, publicly supplied water and industrial self-supplied water are the most important needs in the achievement of Area mixed objectives in the Region. Water is plentiful in the Region but it must be distributed geographically and seasonally to meet the widespread and large needs. Distribution of the Region's water can be most beneficial only if the water quality is maintained. Each of these needs is considered to be important to the achievement of the mixed objectives of fourteen Areas in the Region: water quality maintenance in Areas 2, 4, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18 and 19, publicly supplied water in Areas 1, 3, 4, 5, 6, 9, 10, 11, 12, 13, 15, 16, 17, 19 and 20; and industrial self-supplied water in Areas 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 15, 16, 17, 20 and 21. Water quality maintenance is the key need in the Region as it will help the major needs to be fulfilled in sixteen Areas (all Areas except 6, 10, 11, 14 and 20).

Other needs among the more important of the Region include visual and cultural environment, water recreation, fish and wildlife and power plant cooling needs.

Power plant cooling needs will grow most rapidly while water quality maintenance and industrial self-supplied water needs wil also grow rapidly throughout the planning period.

Water quality control facilities are the most important devices in the Region for the fulfillment of Area needs. These devices are considered to be important in fifteen Areas (1, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18 and 19) and key to the success of other devices in five Areas (3, 4, 9, 13 and 15). The devices to attain high water quality are now or will soon be available, although cost reductions should be sought and large scale operations encouraged. Monitoring facilities will be necessary on a Regional basis.

Devices for the other important needs are generally well known but of varying success. The limited land use controls available for protection of the visual and cultural environment are not adequately applied.

Desalting facilities for water supply are expensive and need further research to reduce costs and negative environmental effects.

Reservoirs will continue to be primary sources of additional flows for water supply. Power plant cooling needs will be met in part by increasing numbers of cooling towers and ponds. Increased evaporative losses will necessitate reservoir storage capacity to replace this consumptive use during periods of low streamflow. This need can be reduced only by finding economically competitive power sources that require little or no water for cooling.

Areas

Programs for the 21 Areas are discussed in detail in Annex 1 and only the highlights are presented here.

The Delaware River Basin (15) is the Area with the greatest number of large needs followed closely by the Susquehanna River Basin (17). The greatest number of fastest growing needs occur in the Potomac River Basin (19), however, and the greatest number of largest per capita needs occur in the St. John and Penobscot River Basins (1 and 2). Southeastern New England (9) and Southeastern New York Metropolitan Area (13) have the largest number of needs considered to be key to the fulfillment of other needs in these Areas. The greatest number of needs considered important to the achievement of an Area's mixed objective occur in the Androscoggin River Basin (4).

Southeastern New England (9) has the largest number of devices considered to be important to fulfillment of its needs, with the Delaware and the Susquehanna River Basins (15 and 17) close behind.

Three Areas will have the greatest number of needs that when fulfilled will produce large benefits: the Penobscot River Basin (2), the Connecticut River Basin (8), the Delaware River Basin (15) and Coastal New Jersey (16).

The Delaware River Basin (15) will have the largest costs over the planning period for fulfillment of all its needs. Close to this Area in costs will be Southeastern New York Metropolitan Area (13).

Special Patterns

Special problems occur in the Region because of unique characteristics possessed by several resources, needs and management procedures. Waterfowl migration routes in the North Atlantic and nearby Regions must be preserved if ducks and similar migratory species are to be maintained at satisfactory levels throughout the eastern portion of the Nation. Retention of wetlands and maintenance of water quality will be the primary means of preserving these routes.

Anadromous fish will also require special attention if they are to regain some of their original stature in the Nation's sport and commercial fisheries. Water quality maintenance and the use of fish ladders and stocking are the primary management techniques for these fish that include Atlantic salmon and striped bass.

Pollution of the Region's rivers and streams must be controlled if estuarine dependent fish, shellfish and crustaceans are to survive and if the Region is not to continue contributing to the despoilment of the coastal waters of the Atlantic Ocean. Water quality management that includes advanced waste treatment is the primary means of achieving this control.

Visual and cultural resources must be managed more equitably throughout the Region and Nation. Scenery that occurs around and close to large population centers must be retained for public use and managed more intensely. This approach will provide more people with greater visual and cultural opportunities and take pressure off highly scenic areas.

PROGRAM IMPLICATIONS

General Problems

National Income will be the most easily obtained objective in the NAR under the present procedures for water resources management. There will not be adequate and equal recognition of all objectives during program planning and implementation until formulation and evaluation procedures that are impartial for all objectives have been generally agreed on and installed into decision making processes. The proposed new principles and standards of the Water Resources Council would fill part of this void.

A second problem concerns the emphasis placed by this Study on the natural environment under the Environmental Quality objective. This emphasis is not intended to detract from the value and importance of well designed man-made environments, but it is intended to give emphasis to the natural environment that has received little direct attention in the past (including parks and other forms of man-made "natural" environments). A great deal of extra attention must also be given man-made environments in future studies. This attention to architectural esthetics is particularly absent during the present planning and design stages of water resources management.

Future conflicts over objectives in the Region will probably intensify as Environmental Quality and Regional Development become increasingly acceptable objectives on a local and sub-regional basis. People will pursue these objectives with greater intensity as they realize that the redistribution of funds and resources implied by each can be accomplished only on a limited basis.

Several needs of the NAR program will be fulfilled with greater difficulty than the others. Fish and wildlife needs will be difficult to fulfill as fish and wildlife management programs will have to compete with more socially oriented needs of the future. Water quality maintenance and visual and cultural needs will be difficult to fulfill because of the size and the large costs of the programs to fulfill these needs. Disputes will be frequent here, not just over budgets, but also over the equal application of water quality regulations and equal distribution of quality environments throughout the Region.

Some devices of the Program may also be used with difficulty. Flood plain management will become the most important device to reduce flood damages. Experience has shown, however, that local flood plain management activities are not always successful and will require special impetus.

The general absence of coordination between planning efforts for different needs in the Region has been found to be of increasing concern. The wide range of requirements and policies following from all Federal and state agencies often leads to duplication and confusion. Planning cannot be realistic without the passing of information between agencies concerned with the same need at various government levels and agencies concerned with different but interrelated needs. Housing and other urban needs must be included in future comprehensive water resource planning efforts. Comprehensive planning for water recreation and drainage control must be redirected so that they are more concerned with urban and metropolitan problems.

Finally, findings and recommendations of the NAR Study must be carefully used for two reasons. The definitions of needs and program elements have not been standardized and particular care must be taken in using figures especially for visual and cultural and mainstream flood damage reduction. Also, the projections are based on assumptions and constraints that deal with resources on a Regional basis. Distortions may, therefore, occur in the resulting projections on a local basis and disaggregation of projections and other information in this Report is not recommended.

Deficiencies

Several shortcomings that will affect the quality of portions of the Programs should be noted. The more basic shortcomings are the lack of information on several of the planning needs and of repetition to obtain feedback during the plan formulation process.

Multiple objective planning requires sets of alternatives for all planning elements so that choices can be made among the alternatives to achieve the desired objectives and the largest net benefits under the objective mixes. The scarcity of information for all types of benefits and for non-monetary costs is a problem affecting all needs. When information is missing, however, for alternative levels of needs and alternative devices the flexibility of the planning process is significantly reduced and necessary trade-offs cannot be achieved among objectives, among needs, among devices and between objectives, needs and devices.

Alternative levels based on different objectives were not used or were missing for several of the Study needs that included water quality maintenance, rural water supply, hydroelectric power generation, recreational boating, fish and wildlife and flood damage reduction. It was agreed that differences in the need projections for rural water supply would be very small and could be ignored. The lack of alternative levels for the other needs reflects legal and technological constraints.

The need for maintaining legal standards of water quality under any and all objectives is the rationale for a single level of water quality maintenance needs. Hydroelectric power generation needs are constrained to one level by the limited numbers of hydropower sites. Variations in flood damage reduction needs are limited by the existing flood plain development.

These needs with single or limited levels were considered by the responsible agencies to reflect an already appropriate mixed objective. The standards for water quality, for instances, have already gone through a lengthy review process.

Variations in the levels of other needs, including fish and wildlife and recreational boating needs were constrained by the lack of knowledge on the causes of variations in these needs. Additional flexibility for all of these needs was provided by giving information on alternative types and quantities of devices. Included among these were alternative devices for water quality maintenance (only some of the devices), hydroelectric power generation (siting of the devices), recreational boating and flood damage reduction.

Those devices for which no alternative levels were provided for three objectives included secondary and advanced waste treatment; acid mine drainage control; mainstream flood plain management, pump storage, land treatment for erosion protection, drainage practices, facilities for recreational boating, recreation development, parking and trails, all biological devices, change project design load, and removal of projects.

Two additional problems with data affect the applicability of Regional projections to the smaller geographic portions of the Region. Historical data is often not of equal quality for all portions of the Region and the assumptions for projections may not be applicable to all portions of the Region. These data problems are amplified for those needs which are fulfilled in locations far from where the needs originate. The needs which have these data problems to the greatest extent in the NAR include power plant cooling, fish and wildlife, water recreation and mainstream flood damage reduction.

The last significant problem with Program data concerns the base (or present) year of the projections. Most projections are based on historical data that includes no information past 1967.

Several devices were not given the attention they deserved during the Study because of the lack of information on their use and the size of the studies required for the results to be useful. Included among these devices are water pricing, re-use and other means of control, and legal and institutional arrangements.

The last significant shortcoming concerns the deficiency in the number of reiterations performed with the computer models. The sensitivity of projections to changes in the assumptions and data can be treated by repeated runs of these models. Such reiterations help planners make their choices between alternatives. The lack of time and money decreased the chance of making such computer runs and of obtaining a greater amount of review of the results by the Plan Formulation Work Group.

Conflicts

There will be increasing numbers of conflicts in the Region over water and related land resources. These conflicts will concern competition for the use of resources, the decreasing availability of resources, the various objectives people have for the use of resources and the means by which needs will be fulfilled. It is important to understand while resolving conflicts that arbitrary restriction of alternatives reduces the ability to manage and plan the available resources. The Coordinating Committee has identified the following conflicts that are likely to become important in the future and likely to be central to the major program decisions that will be required.

Under the mixed objective Program, reservoir storage for all purposes would increase sharply during the planning period. The requirement, including flood damage reduction control and instream hydroelectric power generation, would rise from a total of about 3 million acre-feet in 1980 to a total of about 20 million acre-feet in 2020. This does not include almost 2 million acre-feet in the Tocks Island and Beltzville (Area 15), Raystown (Area 17) and Gathright (Area 21) projects, which are assumed to be in operation before 1980. Although the total existing storage in NAR has not been estimated, the above can be compared with existing usable storage on the order of 15 million acre-feet in reservoirs and controlled lakes of at least 5,000 acre-feet capacity.

This large increase in storage in the NAR can be expected to create many conflicts such as those with certain publics that, for environmental reasons, have grown disenchanted with almost any new reservoir. All storage development would alter flow patterns in downstream channels and the outflow regimen at the coastline. Possible conflicts with enjoyment of the environment in the immediate area of reservoir construction might be due to factors such as loss of fish and wildlife habitat, scenic and other visual and cultural attributes, certain types of recreational opportunities and some natural water quality characteristics. Downstream, the benefits of reducing flood flows and providing minimum flows to satisfy withdrawal and instream demands may be in conflict with certain biological, recreational and other resources related to the prevailing historic flow regimen. In general, the more impoundments on a river, the greater the probability of significant alteration of the ecology.

In connection with the estuaries, conflicts arising from the development of tributary river basins may be quite varied depending upon the type and degree of development and the ecology of the coastal area. River regulation that modifies extremes in flow would tend to stabilize ecologic conditions, and could control salinity and limit the advance of marine predators and parasites. The degree of such conflicts may hinge to a large extent on fulfillment of water quality maintenance needs.

Potential storage requirements are highest in Areas 1, 7, 8, 12, 15, 17 and 19. Even with its large size, over 8 million acre-feet, the authorized Dickey-Lincoln School multi-purpose project in Area 1 includes only some of the conflicts related to storage development. This project would cover over 120 miles of the St. John River, much of which is rugged and not easily accessible. The two reservoirs involved here would inundate many miles of white water canoeing river, some trout fishing, and land and water biotic communities. On the other hand, features such as more accessible fishing in the cold water lake, downstream water supply, low-flow augmentation and flood control, provide large environmental as well as economic benefits.

In other Areas, such as 9 and 14, the conflict of storage development with expanding urbanization is particularly pertinent. Development here may be practically prohibitive in the near future, leading to pressure for import of water from nearby Areas and new conflicts. Also, in these and several of the other coastal areas containing large urban centers, a factor in the development/preservation conflict is that water of high quality is required but very little reuse is possible due to the location of outfalls in and near saline waters.

In Areas 1, 7, 10, 16 and 18 storage requirements, while not as high as in the larger Areas, are high in comparison to the Areas' potentials for maximum development of water (see Figure 22, page 97). Various conflicts may arise in these Areas because of this situation. In Areas 1 and 7 there already exist a great deal of flat water so that additional reservoirs in these Areas will use the remaining valleys and reduce the environmental diversity. In Area 10, the new development would actually be such a large portion of the Area's flat lands that the reservoirs may interfere with ecological and recreational uses of upland wildlife areas.

Most conflict with storage development occurs in areas of high natural quality where extensive coldwater fisheries exist and where recreation revolves around natural wildlife experiences. Prime examples of this conflict might be the upper Merrimack River (Area 7) and the upper Connecticut River (Area 8). In Areas with high recreational pressures, such as 14, 18, 19, 20 and 21, warmwater species are prevalent and are adaptable to lake environs, lessening some aspects of conflict.

In portions of the upper Susquehanna River (Area 17) and the upper Delaware River (Area 15), storage development may not be consistent with full multi-purpose use, particularly for recreation and fish and wildlife because of pollution from acid mine drainage.

Pumped storage for peaking power is a specialized development not usually involving large amounts of storage at any one site. However, circulation of large quantities of water between upper and lower storage sites creates water level fluctuations and in some cases could result in quantities of fish being destroyed in the intake. Individual sites could well conflict with local visual desires and could be objected to because of the use of the power at locations far removed from the site.

The possible conflict related to use at locations removed from the source of development applies as well to storage other than pumped storage. Locally, development for water supply or flood control to benefit downstream interests or even another Area can be expected to conflict with desires for preservation, at the least, and may have significant detrimental ecological and other effects at the location of the resource In this connection, a conflict regarding storage development in Area 12, largely for urban water supply needs in Areas 13 and 14, should be noted. Existing legislative constraints preclude development in parts of the large Adirondack Forest Preserve. Since the restricted area contains many of the larger potential storage sites, smaller, less efficient sites have been considered for this purpose.

Resolution of the conflict in this manner would increase water development costs on the order of $25 million. Other alternatives such as import from outside Area 12 could prove more feasible than development of large numbers of smaller sites provided that any new conflicts could be resolved.

Transfers between Areas increase the possibility for conflict. There may be ecological effects from eliminating periods of high flow because of the increased regulation and development in the originating Area. Similar effects may occur because of the change in the location of outflow on the coast. The largest transfers are expected from Area 7 to Area 9, Area 8 through Area 7 for Area 9, Area 12 to Area 13, and Area 17 to Area 18.

Transfers from Area 12 to Area 13 are not actual interbasin transfers since the Areas are part of the same hydrologic system. This conveyance of water from Area 12 to Area 13, however, must be treated as an interbasin transfer because significant impacts and conflicts could occur. Impacts may occur in the Hudson River due to a change in the location of the salt front and social and instititutional conflicts are likely to occur of the types associated with similar transfers. Similar small effects would be connected with transfers from Area 17 to Area 18 since the outflow would still be largely to the upper part of Chesapeake Bay. Of more significance is the C&D Canal connecting the Chesapeake Bay with the Delaware River Estuary. Tidal variations cause a net outflow to the Delaware Estuary, and the eventual enlargement of canal dimensions for navigation could conflict significantly with the ecology of the two water bodies if large amounts of fresh water were diverted.

The prospective transfer from Area 12 to Area 13 is large but only about 50 percent greater than the existing diversion capacity. For this reason, the effects may be of less concern. Provision has been made for sufficient outflow from Area 12 to maintain the position of the salt front in the lower Hudson River. Past increases in transfers between these two Areas have met with strong public reaction. This points towards similar problems for future transfers.

The most significant diversion might be from Area 7 to Area 9 because of its size and because the outflow may be rather far from the Merrimack River. The possibility exists that ecological changes arising from the increased outflow in Area 9 would be as significant as the effects of decreased fresh outflow in Area 7. Resolution of these conflicts may lie in the return of water to the originating Area.

Substantial desalting is indicated on the Delmarva Peninsula in Area 18 and in the lower portion of Area 21. Conflicts are likely between the desalting facilities and esthetic desires, attractive coastal sites and marine environments. Alternatives to desalting include lengthy and costly diversion facilities that would promote new conflicts, particularly among resource users.

Ground water use is expected to more than double during the NAR planning period. The water table in the Region is generally close to the surface only along streams and elsewhere lies 10 or more feet below the surface. Lowering the water table in this situation should result in only subtle, if any over-all environmental changes. Locally, swamps and bogs could be drained to some extent when ground water is developed nearby. Ecological conflicts in such situations might involve loss of wetlands and fish spawning grounds and inland movement of salt water. Conflicts with use might arise in some locations from contamination of ground water by domestic and industrial wastes.

In the coastal areas of high ground water use such as Long Island, there is a close interrelationship between water supply, waste water disposal and coastal water quality standards and salinity concentrations. Strategies for development must recognize this and provide for the resolution of conflicts.

A conflict of increasing importance in the NAR will be between development and preservation of the coastal shorelines. This conflict will be very intense in highly populated Areas such as 9, 10 and 13 where the desired uses of the coast vary from industrial and urban expansion, water recreation and high quality landscapes. To some extent these types of use conflicts can be resolved on a case-by-case basis by site location and design of facilities. More broadly, the conflicts can only be resolved by obtaining agreement for and firm control of the final uses.

Conflicts between water withdrawal needs will become increasingly common in several Areas. Irrigation water needs will be in increasing conflict with other water withdrawal needs in Areas 13, 16 and 18 as urbanization and industrialization rapidly increase. Consumptive losses from fulfilling power plant cooling needs will be in conflict with other water withdrawal needs and particularly in Areas such as the Potomac (19), Delaware (15) and Connecticut River Basins (8) where several power plants are soon to be installed near industrial centers.

Urbanization of watersheds will increasingly create conflicts in the Region because of changes in hydrologic characteristics of the areas that result in more rapid runoff, greater pollution and drainage and erosion problems. Characteristics of soil type, slope and cover will increasingly determine the use of lands but will create conflicts as land use controls are sought and enforced.

Water recreation needs are projected to increase rapidly in the Region and several large conflicts will occur. Water supply reservoirs, for instance, are generally not used for recreation in the NAR but with proper precautions against pollution and with potable water treatment these facilities could be used for fishing, swimming and boating. The situation will become increasingly difficult as water recreation and water supply needs compete for limited water resources.

There will also be conflicts between the needs for water recreation of urban populations and the desire of rural populations to maintain undisturbed their local environmental resources and their rural way of life. In many cases these conflicts will have additional overtones of racial, economic and cultural conflicts. The intensity of this type of resource use conflict will depend on the levels of population achieved in the NAR along with the types of amenities and transportation available directly in urban areas.

CHAPTER 10

RECOMMENDATIONS

The Coordinating Committee makes the following recommendations based upon its deliberations, findings, the Report and appendices

1. Research, studies and action programs should be initiated at this time by Federal, state, local and private agencies for the following four purposes

a. First, the programs should strive to reduce the demand for water and related land resources. These purposes can be achieved through:

(1) a National policy of planning for controlling population and economic growth;

(2) the furthering of a resource conservation ethic;

(3) the elimination of existing water pollution and wasteful practices,

(4) the development and installation of recirculation, reuse and low water using equipment and processes in industry, commerce and homes.

b. Second, the programs should develop new institutions that through educational, political, legal and economic means (including pricing and rationing) will.

(1) improve the conservation and allocation of water resources, and

(2) plan and manage land use programs, including the protection of the visual and cultural values of the landscape.

c. Third, the programs should also determine the desires and values held by people in relation to water and related land resources use, development and protection. This information must be used by planners and managers while they make public investment decisions for water resources.

d. Fourth, the programs should develop the qualified personnel and the educated public that will be necessary to make decisions and develop and manage the increasingly complex solutions to the water and related land resources problems of the future. These problems can only be solved through increased training of personnel in fields related to water and land resources management and operation. It is also important that general programs be made available to the public at all educational levels on conservation, ecology and water management. Specialized fields should be emphasized at higher educational levels including natural resources planning, administration and economics; water systems analysis, design and operation; and processes for public decision making, including negotiation and conflict resolution. These programs should be especially oriented towards increasing the staff capabilities of state, regional and local agencies.

2. The 21 Area Programs presented in Annex 1 should be adopted as framework plans for water and related resources in the North Atlantic Region and serve as guides and starting points for more detailed river basin or project planning. In those Areas where more advanced planning has been accomplished (such as in the Delaware and Susquehanna River Basins) these more detailed plans should serve as the guides.

3. Action based on existing plans and programs should be continued for implementation of water and related resource development in the Region, their effect should be measured against the framework Area Programs. Great emphasis must be immediately placed on the implementation of projects for water resources development and management because of the increasing needs, conflicts and planning time.

4. Planning should be initiated or if ongoing continued for four types of programs in the Region.

a. The first programs (type B) include preparation or maintenance of comprehensive, multiple-purpose plans for the protection and development of the following river basins and Areas:

(1) Initiate in the St. John River Basin of Maine (Area 1) a planning study in 1974 to insure that a balanced program protects the unique natural qualities of that Area while permitting regional development for recreation and industry.

(2) Begin in the Merrimack River Basin of Massachusetts and New Hampshire (Area 7) a planning study in 1975 to insure the compatibility of the Area's Program that calls for both environmental protection and water development to meet pressures from the resources poor and populous Southeastern New England Area (Area 9).

(3) Continue in the Southeastern New England Area of Massachusetts, Rhode Island and Connecticut (Area 9) the ongoing planning study for management of the resources of this complex, highly urbanized and populous Area in which all three objectives, in locally different mixes, vie for attention.

(4) Begin in the Hudson River Basin of New York, Vermont and New Jersey (Area 12) a planning study in 1974 to develop a comprehensive management program. This will serve to protect the unique environmental parts of this Area while developing its resources in response to pressure from the population and economic growth of the entire New York – New Jersey metropolitan region (Areas 13 and 14).

(5) In the Southeastern New York Metropolitan Area of New York (Area 13) start a study in 1974 to plan for the services to be provided by water and related land resources in the most populous region of the United States. This study would be in concert with the ongoing Long Island Sound Study and the study recommended for the Hudson River Basin (Area 12). Particular urgency should be given to concurrent planning for project implementation studies (type C) in this Area for the needs considered to be especially important – publicly supplied water, water quality maintenance, water recreation and visual and cultural environment -- and for several needs that have not been given enough attention in the past – fish and wildlife, tidal and hurricane flood damage reduction, and beach erosion control.

(6) Start in Northern New Jersey (Area 14) a study beginning in 1974 to plan for the services that must be provided by water and related land resources in this densely populated and heavily industrialized region, where environmental quality is to be protected and enhanced as much as possible.

(7) Continue in the Delaware River Basin of New York, New Jersey, Pennsylvania and Delaware (Area 15) the planning, updating and plan implementation being carried out in this complex Area where objective mixes vary from state to state and sub-area to sub-area.

(8) In the Susquehanna River Basin of New York, Pennsylvania and Maryland (Area 17) continue planning and plan implementation with the 1971 Susquehanna Basin Plan for the largest river basin in the North Atlantic Region.

(9) In the Chesapeake Bay and Delmarva Peninsula Area of Delaware, Maryland and Virginia (Area 18) accelerate the funding, planning and development of a Chesapeake Bay Hydraulic Model and Scientific Center for this ecologically complex Area.

(10) Begin in the Potomac River Basin of West Virginia, Maryland, Pennsylvania, Virginia and the District of Columbia (Area 19) an updating and review of the 1963 Potomac Basin Plan and all other pertinent studies. Begin in 1973 to modify these plans and programs in consonance with today's objectives and values. Virtually no progress has been made toward implementing the 1963 Plan, the result being a water supply crisis in the Washington Metropolitan Area.

(11) Begin in the Lake Champlain Basin of New York and Vermont (Area 11) a planning study in 1975 to insure that development in this basin enhances Environmental Quality while providing Regional Economic Development. Special attention should be given in this study to the problems of recreation, scenic protection, and the eutrophication problems of Lake George and Lake Champlain.

(12) Continue all other ongoing area and sub-area planning including the Connecticut River Supplemental Study (10 and 13) and the James River Basin (20).

b. The second type of programs are for preparation of Region-wide plans for specific purposes (needs) while maintaining a broad multi-purpose viewpoint. These programs should serve the four needs listed below:

(1) The study of municipal and industrial water supplies should be continued and completed and should evaluate demand constraints as well as development of water supplies for the metropolitan areas of the North Atlantic Region.

(2) A regional study of Water Quality Management should be initiated in 1973 to insure an integrated plan for the maintenance of water quality objectives that are considered to be the most important and key elements of water resources management in the Region.

(3) A study should be initiated in 1975 for the development of a land use plan and for the development of institutions needed to implement such a plan. This study should emphasize the visual and cultural needs and objectives of the Region and yet be broad enough in scope to include all needs that affect land uses on a Regional basis. Several of the land use problems of concern here include, but are not limited to: siting of power and sewage treatment plants; and use of wet lands, coasts, waterfronts and flood plains.

(4) A Regional water recreation plan should be developed beginning in 1976 that takes special cognizance of the problem of the unequal distribution of recreation pressures and resources.

c. Third, specific project studies (type C) should be carried out for implementation of solutions needed to satisfy the key and important needs of those Areas that are not mentioned in recommendation 4a. The Areas and needs for these studies are indicated in Tables 37 and 38 on pages 148 and 169. These implementation studies should be initiated as soon as budget limitations permit and be coordinated with the Regional plans recommended in 4b.

d. The last program should be an update of the NAR Study at 10 year intervals in the years immediately following each census year. The first full updating should be accomplished after results of the 1980 census become available. Such updating should include an analysis of the laws and institutions then existing in the NAR and fit the study output to the institutional framework. A quick updating should be made immediately after the submission of this Report. This updating should include a rerunning of the models with 1970 census data which just became available. This quick updating should concentrate only on sub-regions and on testing major assumptions so that maximum effort can go to Type B studies. All updating should be coordinated with the National Assessment.

5. Research and special studies should be initiated or continued to reduce the uncertainties now existing in water resources management. Priorities for such studies are listed below.

a. Analyses of the efficiency, purposes and effectiveness of government institutions and laws concerning water resources in the NAR.

b. Demand control for water and related land resources.

c. Analyses of water quality parameters to determine their effectiveness in relation to goals, their measurement and their monitoring.

d. Development of improved water and waste water treatment and recycling facilities.

e. Acceleration of flood plain management through education and new means of land control and program implementation.

f. Analyses of the value of the NAR Study and its real and practical applications.

Acknowledgements

COORDINATING COMMITTEE MEMBERS

Department of the Army, Chairman
B.G David S. Parker 1966---1966
B.G. Harry G. Woodbury 1966---1966
B.G. Francis P. Kolsch 1966---1968
M.G. Charles M. Duke 1968---1971
M.G. Richard H. Groves 1971---1972

Department of Agriculture
Richard W. Akeley 1967---1972
Seldon Lee Tinsley 1966---1967

Alternate:
Claude J. Price 1966---1972

Department of Commerce
Alternate.
Richard M. Greening 1966---1969
Edwin W. Weber 1966
Richard L. Walton 1967
John Thomas 1970---1972

Department of Health, Education & Welfare
Ralph J. VanDerwerker 1967---1969
Everett L. MacLeman 1969---1971

Alternate:
Earl J. Anderson 1966
Sylvan C. Martin 1966---1967
Frank Tetzlaff 1966---1971

Department of Housing and Urban Development
Judah Gribitz 1967---1970
W. William Green 1970---1972

Alternate:
Frank A. Batstone 1967---1972
Arthur A. Davis 1966---1967
Jack A. Underhill 1966---1967

Department of the Interior
Mark Abelson 1966---1972

Department of Transportation
George M. Chandler 1968---1970
William R. Riedel 1971---1972

Alternate:
Philip E. Franklin 1968 1972

Environmental Protection Agency
Lester Klashman 1972
Gerald M Hansler 1972

Federal Power Commission
Paul H. Shore 1966---1971
John H. Spellman 1971---1972

Alternate.
Lazur B. Woll 1966
John H. Spellman 1966---1971
Martin Inwald 1971---1972

State of Maine
Austin H. Wilkins 1966---1970
Philip Savage 1970---1972

Alternate:
Raeburn W. MacDonald 1966
Dr. Warren Viessman, Jr. 1966
Edgar A. Imhoff 1969---1970
Austin H. Wilkins 1970---1972

State of New Hampshire
George M. McGee, Sr. 1966---1972

State of Vermont
John E. Cerutti 1970---1972

Alternate:
Reinhold Thieme 1966---1972
Richard H. Macomber 1966

Commonwealth of Massachusetts
Malcom E. Graf 1966---1967
Charles F. Kennedy 1968---1972

Alternate.
Charles H. W. Foster 1966

State of Rhode Island
Alonzo W. Quinn 1966---1968
William I. MacDonald 1968---1971
Robert B. Russ 1971---1972

State of Connecticut
John J. Curry 1967---1972

Alternate
William S. Wise 1966---1967

State of New York
F W. Montanari 1966 1971
John A. Finck 1971 1972

Alternate
Nicholas L Barbarossa 1966 1971
Ambrose F Brennan 1971 1972

COORDINATING COMMITTEE MEMBERS (Continued)

State of New Jersey
Robert A. Roe 1966---1969
Richard J. Sullivan 1970---1972

Alternate:
George R. Shanklin 1966---1970
Robert L. Hardman 1970---1971
Charles M. Pike 1971---1972
Robert E. Cyphers 1966---1972

State of Pennsylvania
C.H. McConnell 1966---1972

Alternate:
Alan J. Sommerville 1966---1972
Maurice K. Goddard 1966

State of Delaware
B.G. Norman M. Lack (USA Ret) 1966---1968
John Bryson 1968---1972

Alternate:
Jack Karanick 1968---1970

State of Maryland
James J. O'Donnell 1966--- 1968
Vladimir A. Wahbe 1968---1972

Alternate.
Paul W. McKee 1966---1972
Dr. Albert R. Miller, Jr 1966---1972

State of Virginia
Julian M. Alexander 1966---1972

Alternate:
Dale F. Jones 1968---1972
Donald B. Richwine 1968---1972

State of West Virginia
Edgar N Henry 1966---1972

Alternate:
John Hall 1966---1972
Bern Wright 1966
Lyle Gillenwater 1966---1967
Houston Wood 1967
M.S. Baloch 1968---1972

District of Columbia
Roy L. Orndorff 1966---1970
Norman E. Jackson 1970---1972

Alternate:
William H. Cary, Jr. 1966---1972
Malcolm C. Hope 1969---1972

Delaware River Basin Commission
James F Wright 1966---1972

Alternate
Dr. C.H.J. Hull 1966---1972

New England River Basins Commission
Malcolm E. Graf 1968---1972

Alternate.
Walter M. Newman 1968---1972

EXECUTIVE SECRETARIES

Burnham Dodge 1966- -1968
Harry E. Schwarz 1968---1972

BOARD OF CONSULTANTS

Mr David W. Auld
Consulting Engineer Former Director of Sanitary Engineering, District of Columbia

Dr Arthur Maass
Professor of Government, Harvard University

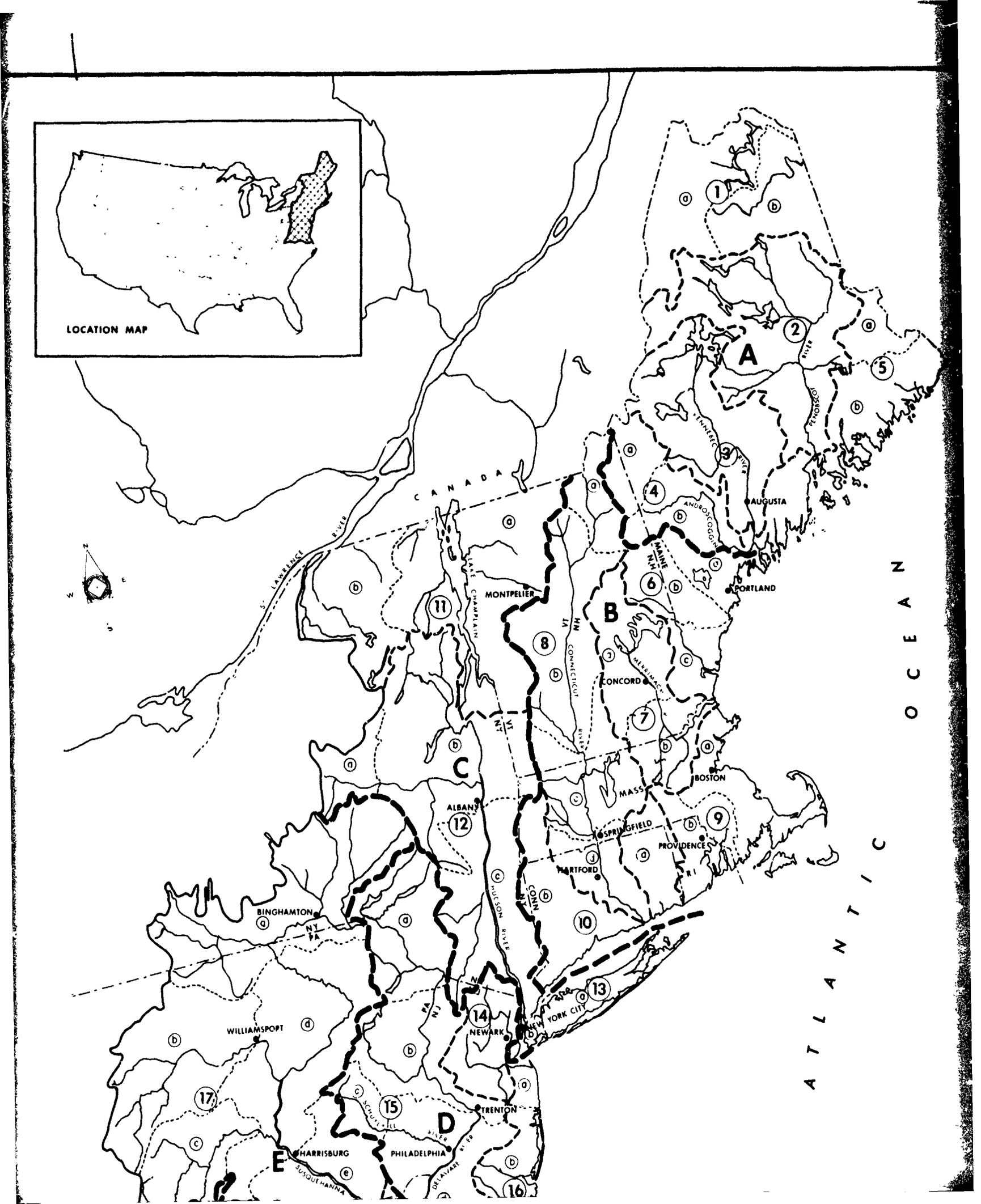
Mr Eugene W. Weber
Consultant, Former Deputy Director, Civil Works, Corps of Engineers

Dr Gilbert F. White
Professor of Geography, University of Colorado

Dr Nathaniel Wollman
Dean, College of Arts and Science, University of New Mexico

Dr. Abel Wolman
Professor Emeritus, Sanitary Engineering, Johns Hopkins University

Others not cited here are cited in Appendix A


LOCATION MAP
CANADA
ST. LAWRENCE RIVER
LAKE CHAMPLAIN
MONTPELIER
AUGUSTA
PORTLAND
CONCORD
BOSTON
ALBANY
SPRINGFIELD
PROVIDENCE
HARTFORD
BINGHAMTON
WILLIAMSPORT
NEWARK
NEW YORK CITY
TRENTON
HARRISBURG
PHILADELPHIA
ATLANTIC OCEAN
A
B
C
D
E
ME
NH
VT
MASS
RI
CONN
NY
PA
NJ
ANDROSCOGGIN RIVER
KENNEBEC RIVER
PENOBSCOT RIVER
CONNECTICUT RIVER
MERRIMACK RIVER
HUDSON RIVER
SUSQUEHANNA RIVER
DELAWARE RIVER
SCHUYLKILL RIVER

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY

10 0 10 20 30 40 Miles
Scale

Legend

- Sub-region boundary
- Basin or area boundary
- Working sub-area boundary for plan fo